2017 Gulf of Mexico Red Snapper Recreational Season Length Estimates
NOAA Fisheries, Southeast Regional Office

Executive Summary

The Gulf of Mexico (Gulf) red snapper recreational fishing season opens each year on June 1 and closes when the recreational annual catch targets (ACTs) are projected to be reached. Amendment 40 to the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico (RF-40) established separate annual catch limits (ACLs) and ACTs for the federal for-hire and private angling components. The private angling component includes charter vessels fishing in state waters. Prior to June 1 each year, NOAA Fisheries notifies the public of the projected closing dates for each component.

Using data from the Marine Recreational Information Program, Louisiana and Texas creel surveys, and the Southeast Region Headboat Survey, 2016 landings were summarized and compared to the 2016 ACTs. The total federal for-hire landings for 2016 were 2,134,005 pounds whole weight (lb ww). These landings were 299,995 lb ww (12 percent) less than the component ACT and 907,995 lb ww (30 percent) less than the component ACL. The total private angling and state charter landings for 2016 were 5,187,901 lb ww. These landings were 1,867,901 lb ww (56 percent) greater than the component ACT and 1,037,901 lb ww (25 percent) greater than the component ACL. Further, the total recreational ACL was exceeded by 129,906 lb ww (2 percent).

The observed federal season catch rates for 2016 were within the range in the 2016 projections (SERO-LAPP-2016-04). The private angling component overage was attributable primarily to underestimation of state catches, due in part to the extension of state seasons following the announcement of the 2016 federal seasons and the extension of Alabama, Mississippi, and Louisiana jurisdictional boundaries from 3 to 9 nautical miles (nmi) by the 2016 Department of Commerce Appropriations Act.

Due to a recent legal decision regarding Amendment 28 to the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico (RF-28), the allocation for the recreational sector will revert to 49 percent from 51.5 percent. Additionally, accountability measures require that a component that exceeded its ACL in a year must have the component ACL in the next year reduced by the amount of the overage of the total ACL. Therefore, the private angling ACL is adjusted for a 129,906 lb ww payback due to the ACL overage in 2016. Each component ACT is set 20 percent below the ACL. The ACTs for 2017 will be 2,278,000 lb ww for the federal for-hire component and 3,004,075 lb ww for the private angling component.

A tiered projection approach was taken for forecasting red snapper recreational average weight and catch rates for 2017. State season average weights and daily catch rates for 2017 were based on observed values from 2016. Two projection scenarios were developed for determining federal season length for the private angling and federal for-hire modes; one based on 2016 data and one based on regression methods using data from 2004-2016.

Due to inconsistent state seasons, approximately 81 percent of the private angling component ACT is anticipated to be caught during state seasons in 2017. Projected federal season lengths

for 2017 are 48-49 days for the federal for-hire component and 2-3 days for private angling component. Under these season lengths, 19-21 percent of bootstrapped private angling model runs and 2-6 percent of bootstrapped federal for-hire model runs exceeded the component quota. If all Gulf states adopted regulations consistent with the federal private angling component season, the federal private angling season length could be extended nearly six-fold, for a total season of 10-13 days. Because state season landings are attributed towards the private angling component quota, state consistency would not impact the federal for-hire component season length.

Introduction

Red snapper are managed in Gulf federal waters from the west coast of Florida to Texas by the Gulf of Mexico Fishery Management Council (Council). On April 20, 2015, a final rule (80 FR 14328) established a red snapper recreational ACT by applying a buffer of 20 percent to the recreational ACL, which is based on the Council's ACL/ACT control rule developed in the Generic ACL Amendment (76 FR 82044). The ACL/ACT control rule is used to determine the appropriate target catch levels, accounting for management uncertainty, to maintain catches at or less than the ACL (quota). In 4 of the last 6 years (2011-2016), landings exceeded the recreational quota. The final rule (80 FR 14328) also revised the procedure for determining the recreational season length (closure date). The red snapper recreational closure dates are now based on when the recreational component ACTs are projected to be met. Using the ACT instead of the quota to set the season length serves as an in-season accountability measure (AM); projections indicated the 20 percent buffer reduced the probability of exceeding the recreational quota during a fishing year from 50 percent to 15 percent (SERO-LAPP-2014-04). This final rule also revised the recreational AMs to include a quota overage adjustment (payback). If red snapper are overfished and the recreational quota is exceeded, then in the year following the overage, the recreational quota will be reduced by the amount of the recreational quota overage in the prior fishing year, unless the best scientific information available determines that a greater, lesser, or no overage adjustment is necessary. If the recreational quota is adjusted, the recreational ACT will also be reduced to maintain the 20 percent buffer.

On May 22, 2015, the final rule for RF-40 was effective. This rulemaking provided a basis for increased flexibility in future management of the recreational sector, and reduced the chance for recreational quota overruns, which could jeopardize the rebuilding of the red snapper stock. The rule established sub-quotas for federally permitted for-hire vessels and private anglers who fish for red snapper. The federal for-hire component is comprised of all for-hire operators with a valid or renewable federal reef fish charter vessel/headboat permit. The private angling component is comprised of private anglers and other for-hire operators who do not have a federal reef fish charter vessel/headboat permit. The rule implemented sub-quotas using allocation of 42.3 percent to the federal for-hire component and 57.7 percent to the private angling component. Based on federal regulations (50 CFR 622.41 q(2)(ii)), if red snapper recreational landings exceed the total recreational quota and red snapper are overfished, the applicable recreational component's quota will be reduced by the overage as will the total recreational quota. For example if one component exceed that component's ACL and the total recreational quota was exceeded, the payback provision only applies to the component that exceeded the ACL. The component ACT is also adjusted to maintain the 20 percent buffer.

The red snapper federal for-hire and private angling recreational fishing seasons open each year on June 1 and close when their respective ACTs are projected to be reached. On May 1, 2015, NOAA Fisheries implemented a final rule increasing the quotas for 2015-2017 and beyond (80 FR 24832) to the highest levels ever for Gulf red snapper. Prior to the 2016 federal opening for red snapper recreational harvest, RF-28 reallocated red snapper harvest between the commercial and recreational sectors from 51:49 percent to 48.5:51.5 percent, respectively. The reallocation was based on changes in recreational data incorporated into the 2014 red snapper update assessment. These changes are attributable to the calibration of the Marine Recreational Information Program (MRIP) catch data. On March 3, 2017, a legal decision in *Guindon v. Pritzk*er by the United States District Court for the District of Columbia vacated RF-28 and remanded the action back to NOAA (Civil Action No. 2015-2256: D.C. 2017). Therefore, in 2017, the allocation for the recreational sector will revert to 49 percent.

Prior to any payback provisions, the ACL for the recreational sector would have been 6,733,000 lb ww, with a federal for-hire ACL of 2,848,000 lb ww and private angling ACL of 3,885,000 lb ww. However, the recreational ACL and private angling ACL were exceeded in 2016 (and red snapper is overfished), triggering payback of the overage by the private angling component. After the payback provision, the adjusted private angling ACL is 3,755,094 lb ww and the adjusted ACL for the recreational sector is 6,603,094 lb ww. The ACTs for 2017 are 2,278,000 lb ww to the federal for-hire component and 3,004,075 lb ww to the private angling component. The adjusted recreational ACL and adjusted private component ACL and ACT account for a 129,906 lb ww payback for the private angling component due to the ACL overage in 2016 (discussed below).

Prior to June 1 each year, NOAA Fisheries projects the federal for-hire and private angling season closing dates and notifies the public. If subsequent data indicate that the ACTs have not been reached, NOAA Fisheries may re-open the seasons. The purpose of this report is to provide preliminary 2016 landings, project the 2017 recreational red snapper federal for-hire and private angling fishing season lengths, and to characterize the uncertainty of those projections.

Methods

State Regulations

This analysis assumes bag limits and size limits for Gulf states other than Texas will be consistent with the federal two-fish bag limit and 16-inch total length minimum size limit (MSL), but seasons for all Gulf states will be inconsistent with the federal season (**Table 1**). The Florida Fish and Wildlife Commission is considering a 78-day state waters fishing season, open Saturdays and Sundays starting the first Saturday in May, then opening continuously starting the Saturday before Memorial Day through the Sunday following Independence Day, then reopening Fridays, Saturdays, and Sundays in September and October, plus Labor Day (Martha Guyas, FWC, pers. comm.). Alabama announced a season in state waters starting May 27 and running through July 31. Mississippi is considering a state season similar to 2016 (Kelly Lucas, MS-DMR/University of Southern Mississippi, pers. comm.). Louisiana opened on February 1 and will manage towards targets of 18.41 percent of the adjusted private angling component ACL

and 11.60 percent of the federal for-hire component ACL (J. Shepard, LA-DWF, pers. comm.). In 2017, as in previous years, Texas will be open year-round in state waters with a four-fish bag limit and a 15-inch total length MSL (Robin Riechers, TPWD, pers. comm.). The projected private angling federal season lengths account for landings from state waters by private anglers and non-federally permitted charter vessels during state seasons to avoid a quota overage.

Data Sources

Recreational red snapper landings, catch rates, and mean weights were obtained from four data sources (**Table 2**):

1. MRIP, including the for-hire charter survey.
2. Southeast Region Headboat Survey (SRHS).
3. Louisiana Department of Wildlife and Fisheries (LDWF) creel survey (LA Creel).
4. Texas Parks and Wildlife Department (TPWD) charter and private/rental creel survey.

MRIP for-hire (charter only) and private angler red snapper landings are estimated using a combination of dockside intercepts (landings data) and phone surveys (effort data). Landings are estimated in both numbers and pounds whole weight by two-month wave (e.g., Wave 1 = Jan/Feb, …, Wave 6 = Nov/Dec), area fished (inland, state, and federal waters), mode of fishing (charter boat, private /rental boat, or shore), and state (west Florida, Alabama, Mississippi, and Louisiana). Uncertainty in MRIP mean estimates in average weights, numbers of fish landed, and pounds of fish landed is expressed as percent standard error (PSE). MRIP has replaced the Marine Recreational Fisheries Statistics Survey program as the primary methodology for collecting and estimating recreational catches in the Gulf. In 2013, MRIP implemented changes to the Access Point Angler Intercept Survey (APAIS). These changes to APAIS required a recalibration of historical landings to account for biases in the sampling time period; these re-calibrated landings were incorporated into the SEDAR-31 Update (2014) stock assessment and were used to generate the inputs for the 2016 season length projections in this report. MRIP landings in numbers, with associated variance, and landings in pounds for 2004-2016 were obtained from the NOAA Southeast Fisheries Science Center (SEFSC) Recreational ACL Database (ACL Data; accessed March 2017) and recalibrated for the APAIS adjustments used in SEDAR-31 Update (2014). The ACL Data does not provide estimates of variance for landings in weight; estimates of PSE were obtained directly from MRIP (http://www.countmyfish.noaa.gov/) and converted to variance. Although this variance does not correspond exactly to the assigned weights in the ACL Data, it may be a reasonable proxy.

Headboat landings are collected through logbooks completed by headboat operators and submitted to the SRHS. Landings (lbs ww) are reported by vessel, day/month, and statistical reporting area (i.e., area 18 = Dry Tortugas off west coast of Florida, …, area 27 = Southeast Texas). Landings from vessels participating in the 2014 and 2015 Headboat Collaborative Exempted Fishing Permit (HBC) were included in the SRHS data. No estimates of uncertainty are generated by the SRHS; the magnitude of expansions between reported and expanded landings from the SRHS was used as a proxy for uncertainty in headboat catch rates. In recent years, these expansion factors were very small (<5 percent), as nearly all vessels were compliant with reporting requirements. Headboat expanded landings were obtained through 2016 from the

ACL Data. Headboat unexpanded landings were obtained from the SRHS program's "CRNF" file (accessed Mar 2017). Variance in headboat average weights was assumed equivalent to charter average weight variance, by state.

LA Creel provides estimates of the number of red snapper landed in Louisiana during the 2014-2016 recreational seasons. Dockside interviews were conducted by state personnel at sites that are stratified by fishing activity (Offshore Charter, Offshore Private Angler, Inshore Charter, Inshore Private Angler). Stratifying dockside sampling for sites where anglers commonly land offshore species increased the probability of encountering anglers landing red snapper. To estimate fishing effort of private anglers, LDWF contact a stratified random portion of saltwater licensed anglers. Saltwater licensed anglers holding a Louisiana Recreational Offshore Landing Permit were surveyed at a higher rate than those not holding the permit. By doing so, the probability of contacting a saltwater angler fishing offshore species such as red snapper was increased. Other strata include southeast Louisiana, southwest Louisiana, north Louisiana, and out-of-state anglers. Anglers were surveyed by phone and/or e-mail on a weekly basis and asked if they fished, how many trips were taken the previous week, the basin they fished (offshore is considered a basin), if they landed at a public site, what time they returned to the dock, and whether they fished on a paid charter. The randomly selected saltwater anglers were notified by e-mail each Monday of their selection to be surveyed. Those selected anglers had the option to answer the effort survey questions by reply e-mail. E-mail non-respondents were contacted by phone. Charter captains holding a Louisiana Guide License were also contacted weekly by LDWF to collect information on the total number of for-hire trips they took the previous week. Those captains holding a Louisiana Recreational Offshore Landing Permit were surveyed at a higher rate than those not holding the permit. Charter captains had the option to respond via e-mail prior to LDWF personnel contacting them via phone. Estimated landings were produced for each sector based on observed catch rates and estimated fishing effort (as adjusted for private anglers not possessing a Louisiana saltwater fishing license or charter captains not having a Louisiana guide license). Uncertainty in LDWF survey weekly estimates of fish landed is expressed as relative standard error (RSE) and was converted to variance. Estimated landings in weight were calculated by multiplying landings in numbers of fish for that season and sector by their average weight. Average weight from LA Creel is determine using biological samples from the month of the survey intercept week or the entire year if samples from that month are not available. Variance in LA Creel mean weights was determined directly from their biological sampling data. LA Creel data were used in projections when MRIP estimates were not available from the ACL Data (i.e., private mode 2014 and 2016, charter mode 2014-2016). The LA Creel survey is currently under review and undergoing certification from NOAA Fisheries; preliminary findings suggest no significant difference in red snapper landings between LA Creel and MRIP private angler mode survey estimates in 2015 (J. Shepard, LDWF, pers. comm.).

The TPWD creel survey generates estimates of landings in numbers for charter vessels and private angler mode/rental boats fishing off Texas. Landings are reported in numbers by high- (May 15-November 20) and low-use (November 21-May 14) time periods, area fished (state versus federal waters), and mode of fishing (charter versus private angler mode). TPWD landings in numbers and pounds for 2004-2015 were obtained from the ACL Data. High- and low-use estimates of uncertainty were obtained from TPWD staff as coefficients of variation that were converted to variance and parsed to wave using ratios from the ACL Data. TPWD staff

also provided preliminary 2016 landings for this analysis, which were parsed to MRIP wave using 2015 TPWD data from the ACL Data. SEFSC assigns mean weights to TPWD data using MRIP data from LA when available or the other Gulf states (in aggregate) when MRIP data from LA are not available. A similar approach was applied to TPWD mean weight for 2016 and for variance in TPWD weights for 2004-2016.

For all sources, catch rates were expressed as landings in numbers of fish per open day, and were separated into federal and state season catch rates. Federal and state season landings, catch rates, and mean weights from 2004-2016 were obtained from the various data sources described in **Table 2**. Landings from inconsistent state seasons were partitioned into state and federal season landings. Landings were assumed to originate from state seasons if they were from waves during which the federal season was closed. For states other than Louisiana, if the federal season was open during a wave but a state season was open during days outside the federal season in that wave, federal season landings were considered to be federal waters landings plus a portion of the landings in state waters computed from the ratio of the federal season length in the wave to the state season length in the wave. For example, if the federal season were open for 30 days in a 60-day wave, and the state season was open for the entire wave, 100% of the landings originating from federal waters and 50% of the landings originating from state waters would be attributed to the federal season and the remaining 50% of state waters landings would be attributed to the state season. If the state season ended before the federal season in a wave, then all landings were assumed to come from the federal season. For Louisiana, LA Creel weekly data were used to parse landings between in-season and out-of-season, assuming a uniform distribution of landings within the week. Following the allocation decisions made in RF-40, for-hire landings from outside the federal season that were attributed towards the state seasons were counted towards the private angling component's quota, as they were assumed to originate from charter vessels without federal permits. All headboat landings were assumed to originate from the federal season, regardless of date landed.

2016 Landings

In 2016, the red snapper recreational ACL was 7,192,000 lb ww, and the ACT was 5,754,000 lb ww. The federal for-hire component season was open for 46 days, from June 1-July 16, and the private angling component federal season was open for 11 days, from June 1-June 10 (80 CFR 25583)) following a two-day season extension due to Tropical Storm Colin (81 CFR 13909). Additionally, Florida had an 85-day state water season, Alabama had a 66-day state water season, Mississippi had a 102-day state water season, and Louisiana had 279-day state water season. Alabama, Florida, Mississippi, and Louisiana all had a 2-fish bag limit and a 16-inch MSL. The state of Texas had a year round (365 day) state waters season with a 4-fish bag limit and 15-inch MSL.

2017 Projected Catch Rates and Mean Weights

A tiered projection approach was taken for forecasting recreational red snapper average weight and catch rates in the Gulf for 2017. Since 2007, the federal recreational fishing season has decreased from 194 days to 9 days (2014 season length), in part due to increasing daily catch rates as the federal season is shortened, increasing average weights as the red snapper stock rebuilds, and extended fishing seasons in state waters (**Figure 1**). State and federal season

landings were converted to daily catch rates assuming a uniform distribution of landings across open days within the wave. Average weights were computed for in-season and out-of-season landings by state/region and mode. Separate models were developed for each state because of differences in state regulations in recent years. Different projections were done for headboat, charter, and private angler modes to account for differences in the effort dynamics of these modes, the implementation of RF-40, and the availability and completeness of data.

Prior to the 2016 season, the US Congress passed the 2016 Department of Commerce Appropriations Act, which temporarily extended red snapper management jurisdiction for Alabama, Mississippi, and Louisiana from 3 nmi from shore out to 9 nmi from shore. Under subsequent continuing resolutions, this jurisdictional extension is anticipated to remain in effect during summer 2017. Catch rates and average weights anticipated during assumed 2017 state seasons (**Table 1**) were projected based on observed 2016 data, as 2016 was the most recent data and the only year where the state water jurisdiction for red snapper in Alabama, Mississippi, and Louisiana extended to 9 nmi. Catch rates and average weights were estimated for each wave and were used in conjunction with the days open per wave to estimate total landings in pounds.

Catch rates and average weights anticipated during the 2017 federal seasons were projected using generalized linear regression models implemented using R v3.3.1 (R Core Team 2014), with a Gaussian error distribution on average weights and a negative binomial error distribution on catch rates. Input data for regressions included wave 3 private mode catch rates and waves 3-4 charter and headboat catch rates from 2004-2016, excluding 2010 due to the confounding effects of fishery closures associated with the BP/Deepwater Horizon MC252 oil spill. The year 2014 was also excluded from the headboat data due to the confounding effects of the implementation of the HBC coupled with the short federal season. A suite of suitable models for each state and mode were identified using an exhaustive search method from the R *glmulti* library (Calcagno 2013). The best model was identified by comparing prediction error for all models within 2 AICc points of the minimum (Akaike 1979, Hurvich & Tsai 1989), using cross-validation implemented using the cv.glm function from the R *boot* package (Canty and Ripley 2016). Residual diagnostics were used to verify goodness-of-fit and variable inflation factor tests were used to avoid multi-collinearity. Following Farmer & Froeschke (2015), a second projection run was made by directly applying 2016 federal season catch rates and average weights.

Predictive covariates considered for regressions on average weight and catch rates were: (1) state season lengths, (2) open weekend days, (3) spawning stock biomass (SSB), (4) fuel prices, (5) year in the rebuilding plan, (6) Google trends data, (7) per capita gross domestic product (GDP), (8) red snapper recreational quota, and (9) fishable days based on weather (**Figure 2**). State season lengths were based on state announcements (2004-2016) and 2017 announcements or statements provided by state fishery managers (**Table 1**). Open weekend days were computed based on previous federal season lengths, with Fridays assigned a value of 0.5 and Saturdays and Sundays assigned a value of 1; the 2017 predicted value for regression fits was based on 2017 projected season lengths using 2016 catch rates and average weights. Gulf of Mexico red snapper stock assessment model-estimated and model-projected SSB from SEDAR-31 Update (2014) was included to account for changes in the size and abundance of red snapper, by region (i.e., East: Florida, Alabama, Mississippi; West: Louisiana, Texas) as the population rebuilds.

Mean June-July Gulf Coast (PADD 3) retail gasoline prices were obtained from the US Energy Information Administration (http://www.eia.gov/petroleum/data.cfm#prices), with prices adjusted to 2010 US Dollars (USD) using the annual average Consumer Price Index (CPI) for all US urban consumers from the US Bureau of Labor Statistics. The 2017 June-July mean price was predicted by extrapolating from the January-March 2017 value using the mean ratio for 2004-2016 of January-March to June-July prices. The correlation coefficient for this ratio was 0.87 (CV=0.12), suggesting this is a reasonable imputation. Mean fuel prices may influence the willingness of recreational fishermen to fish further offshore. The year in the rebuilding plan was determined simply as the number of years since the rebuilding plan was revised in 2007, with all prior years coded as zeroes. Rebuilding results in larger, more abundant red snapper. Google trends (www.google.com/trends/) in searches for the phrase "red snapper season" between January and March were explored because red snapper catch rates have been shown to be well-predicted by Google search counts (Carter et al. 2015). Search counts are adjusted by Google to make comparisons between terms easier; each point is divided by the total searches of the geography and time range it represents, with relative popularity scaled on a range from 0 to 100. Per capita GDP was obtained, in 2010 adjusted USD, from historical and projected data from the US Department of Agriculture's Economic Research Service International Macroeconomic Data Set (www.ers.usda.gov). Per capita GDP was included because it is an indicator of the economic status of the United States overall, which may predict the ability of recreational anglers to afford to take trips for red snapper. Recreational red snapper 2004-2016 quotas were obtained from NOAA Fishery Bulletins (http://sero.nmfs.noaa.gov/fishery_bulletins/bulletin_archives/index.html).

Fishable days for 2004-2016 were determined for each state using weather data from the NOAA Data Buoy Center. Spatially-explicit landings locations for red snapper from the Reef Fish Observer Program and the NOAA Fisheries Bottom Longline Survey were used to guide selection of data buoys with sufficient historical time series in areas near core federal red snapper catch locations off each Gulf state. Most buoys had data on hourly or half-hourly intervals from 2007-2016. For many states, multiple buoys were used (**Figure S-1**). Beaufort Scale 5 measurements were used as a cutoff for weather suitable for offshore recreational fishing. Days with mean wind force measurements exceeding 8.75 m/s (17 knots) or mean wave heights exceeding 1.2 m (4 ft) were not considered fishable. The number of fishable days relative to the number of open days was determined for each fishing year. For private angling fishable days, only June measurements were used. For charter and headboat fishable days, June-July measurements were used. To impute missing values and generate predictions for fishable days in 2017, seasonal auto-regressive integrated moving average (SARIMA) models were fit to the data (Box et al. 2013). In a SARIMA(p,d,q)x(P,D,Q) model, the autoregressive component (p) represents the lingering effects of previous observations, the integrated component (d) represents temporal trends, and the moving average component (q) represents lingering effects of previous random shocks (or error). The SARIMA models were implemented using Proc ARIMA in SAS version 9.2 (SAS Institute). All possible combinations of single-difference SARIMA models for landings per day by wave were considered (**Table S-1**). A single-difference SARIMA model only considers a maximum of one differencing term in the annual and one differencing term in the seasonal component. All SARIMA models were fit using conditional least squares. Stationarity tests were used to guide differencing selection. Final SARIMA model selection was guided by the examination of autocorrelations, inverse autocorrelations, partial autocorrelations,

cross-correlations, residual diagnostics, and AIC. Goodness of fit for all SARIMA models exceeded R^2=0.94.

Parametric bootstrapping techniques were used to directly incorporate variance estimates from the surveys into the projection framework for all projections. For the state and federal season model runs based on 2016 data, the mean and variance in catch rates and average weights were used to define distributions of possible values for each observation over 1000 model runs. For the regression-based model run for federal catch rates and average weights, the best model run for each state and mode was iteratively fit to 1000 bootstrapped samples of input data for that state and mode based on the mean and variance for those observations. Regression outputs included the mean and SE for predicted 2017 mean weights and catch rates by state and mode.

2017 Projected Season Lengths

Forecasts of catch rates and average weights from the best-fitting models were incorporated, along with their variance, into a Microsoft Excel-based season length projection model to determine the federal season length under each model scenario. This season length projection model accounted for out-of-season catch rates and state incompatibility with federal season length as described previously, and ensured Louisiana caught their self-imposed quota over the course of the combined state and federal season.

Uncertainty in season length projections was based on the risk of a given season length exceeding the ACL. The percentage of bootstrapped runs exceeding the ACL was tallied for each component ACL. Additionally, the risk of exceeding the ACL was evaluated at different ACT buffers (i.e., 5 percent, 10 percent, 15 percent, and 20 percent) by tabulating the percentage of 1000 bootstrapped runs for each component across all projection scenarios that exceeded the ACL when the season length for the component was set so the mean landings of the 1000 bootstrapped runs would equal the component ACT at a given buffer level.

Results

Total 2016 Gulf recreational red snapper landings are presented in **Table 3**. The total recreational landings in 2016 were 7,321,906 lb ww, an overage of 129,906 lb ww (2 percent). The total federal for-hire landings for 2016 were 2,134,005 lb ww. These landings were 299,995 lb ww (12 percent) less than the component ACT and 907,995 lb ww (30 percent) less than the component ACL. The total private angler and state charter landings for 2016 were 5,187,901 lb ww. These landings were 1,867,901 lb ww (56 percent) greater than the component ACT and 1,037,901 lb ww (25 percent) greater than the component ACL. The observed federal season catch rates for 2016 were within the range projected in SERO-LAPP-2016-04; median values were 14 percent underestimated for the private angling component (range: -19 to +18 percent) and 9 percent overestimated for the federal for-hire component (range: -7 to +35 percent). State catch rates were underestimated for four of five Gulf states (**Table 4A**). Both Alabama and Florida announced longer seasons following the federal season announcement in 2016 (**Table 4B**).

2017 Projected Catch Rates and Mean Weights

Regression model fits and predicted average weights and catch rates are shown in **Figures 3-7**. Residual deviance explained by covariates included in the final model configurations are provided in **Table 5**. SSB was the most consistently useful predictor for average weight trends. Year was the most consistent predictor of trends in catch rates, followed by per capita GDP, year of rebuilding, and fishable days (based on wind speed). Mean weights appear to be stabilizing or declining in the Eastern Gulf (**Table 6**, **Figures 3-5**). Limited data was available for model-fitting in Mississippi (**Figure 5**). Mean weights appear to be increasing in the Western Gulf (**Table 6**, **Figures 6-7**). Catch rates appear to be increasing for all modes off Florida, private mode off Alabama, and all modes in the Western Gulf (**Table 6**, **Figures 3-4, 6-7**). There was little variability in headboat input data in recent years due to near perfect reporting compliance.

2017 Projected Season Lengths

Based on 2016 catch rates and mean weights and 2017 assumed seasons (**Table 1**), the five Gulf states are anticipated to catch 2,452,576 ± 807,754 lb ww (mean ± SD) during the anticipated state seasons in 2017. In 2017, state catches will represent approximately 81 percent of the recreational private angling quota, leaving less than 700,000 lb ww for the federal private angling season. **Table 7** shows projected catch rates and federal season lengths for Gulf recreational red snapper, by mode, assuming the inconsistent state seasons indicated in **Table 1**. The private angling recreational season will be 2-3 days, with a 19-21 percent chance of exceeding the component quota. The federal for-hire recreational season will be 48-49 days, with a 2-6 percent chance of exceeding the component quota. At these season lengths, the overall probability of exceeding the total recreational ACL is approximately 6 percent. If all Gulf states had adopted state seasons consistent with the federal season, the private angling federal season length would be 10-13 days. If RF-40 had not been implemented (no separate component quotas) and all states were consistent with the federal season, the federal season would be 15-19 days.

Figure 8 shows projected 2017 landings by state and mode. Federal for-hire landings originate primarily from Alabama and Florida. Federal private angling component landings originate primarily from Alabama. State private angling component landings originate primarily from Florida and Louisiana.

Without an ACT buffer, the private angling federal season could double in length; however, the risk of exceeding the component quota would increase substantially with reduced component ACT buffers (**Figure 9**). The buffer was implemented as a result of a court order, and could only be removed or reduced if management uncertainty decreases. The federal for-hire projections are more stable due to a leveling off in catch rates and average weights for most states and no need to account for state season landings. As such, the risk of exceeding the component quota for the federal for-hire component is much lower than for the private angling component at the same ACT buffers (**Figure 9**).

Discussion

In previous years, the Gulf red snapper recreational quota has been exceeded for a variety of reasons, including challenges with predicting angler behavior and catch rates, inconsistent state regulations, and increasing fish sizes associated with a rebuilding stock. Projection assumptions have been refined to better account for changes in average weights and daily catch rates. These refinements have led to increasingly more accurate predictions as described in SERO-LAPP-2013-10, SERO-LAPP-2014-04, SERO-LAPP-2015-04, SERO-LAPP-2016-04, and the retrospective analysis in this report. Additionally, the implementation of a 20 percent buffer between the ACL and ACT has accounted for management uncertainty inherent in a protracted fishing season where the majority of landings are estimated by surveys and landings data is delivered to managers after the season ends.

Accounting for catches from state seasons is critical to accurate projections of the federal season. The percentage of private angling catch originating from state waters has increased substantially for most states in recent years as states have expanded their inconsistent season lengths (**Figure 1**). There is considerable uncertainty in 2017 out-of-season state waters catch rates for the season length projection scenarios presented (**Figure S-2**). Uncertainty in 2016 out-of-season state water catch rates and extension of state seasons following the announcement of the 2016 federal season were the primary reason for the private angling component quota overage in 2016 (see **Table 4**). Limited data exist to inform the uncertainty in out-of-season state water catch rates in 2017. Because the state boundary jurisdictional extension from 3 to 9 nmi will remain in effect for 2017, and 2016 was the only season that was subject to that regulatory change, 2016 catch rates and mean weights were used to project 2017 state season landings. If daily out-of-season catches in state waters are higher in 2017 than in previous years, the season lengths presented in **Table 7** may be overestimated. This could happen if more anglers participate in state seasons or if red snapper population rebuilding results in higher catch rates in state waters. Similarly, if the Gulf states implement longer seasons than anticipated following the federal season announcement, as several did in 2015 and 2016, the federal season length estimates presented in **Table 7** may be overestimates for the private angling component.

As with any projection model, the approaches discussed herein are dependent upon assumptions that historical data are accurately estimated and that historical trends are representative of future dynamics. Previous evaluations of Gulf recreational red snapper catch rates have indicated that catch rates increase as the stock rebuilds and the season is shortened (SERO-LAPP-2012-01; **Figure 1**). These dynamics are implicitly incorporated into the generalized linear regression approaches described by this document. Regression modeling approaches for the 2014 season (SERO-LAPP-2014-04) generated a catch rate estimate that was within 3.5 percent of the observed 2014 federal catch rate. Catch rate estimates for the 2015 season (SERO-LAPP-2015-04) were within 4 percent of the observed 2015 federal for-hire catch rate and within 6 percent of the observed 2015 federal private angling component catch rate. Catch rate estimates for the 2016 season (SERO-LAPP-2016-04) were within 9 percent of the observed 2016 federal for-hire catch rate and within 14 percent of the observed 2016 federal private angler mode catch rate. Estimates of uncertainty in projections based on one year of data (i.e., state catch rate projection and '2016 as proxy' federal catch rate projection) are based exclusively on the variability in survey observations for a single year. As such, they do not account for interannual trends associated with the rebuilding of the stock or other covariates. They also do not account for any unanticipated changes in landings survey estimation methodology. Estimated catch rates and

mean weights are based upon APAIS-adjusted MRIP, LA Creel, TPWD, and SRHS estimates and the data used to generate these estimates is consistent with the data used to generate the ACL in the SEDAR-31 Update (2014) stock assessment and with the data that will be used to monitor catch levels relative to quotas in 2017.

Some covariates were consistently useful predictors in regression models of red snapper federal season average weights and catch weights. SSB was frequently a useful predictor of average weights; this is not surprising, as it is an indirect index of the exploitable biomass in the population. Year and year of rebuilding were the most useful predictors for catch rates; this is not surprising, as they indirectly account for both the rebuilding of red snapper with associated increases in the number of available fish along with the compression of recreational fishing effort into increasingly shorter fishing seasons. Per capita GDP was a useful predictor for private catch rates, possibly indicating more anglers on the water during years with favorable economic conditions. Fishable days, as predicted by wind speed, was a useful predictor for both mean weights and catch rates, possibly predicting anglers ability to fish offshore where greater numbers of larger fish may be encountered. Visual inspection of **Figures 3-7** suggests some stabilization in catch rates between the 2013-2016 seasons and reductions in Eastern Gulf mean weights. This may be due to trends in red snapper recruitment, reductions in Eastern Gulf spawning biomass (see SSB trend in **Figure 1**), or possible saturation in effort compression in the 2014 season, which was only 9 days long. Additionally, state seasons in 2013-2016 were longer than the federal season, which may have decelerated effort compression in the federal season or reduced catch rates due to serial depletion of nearshore fishing areas.

In general, season lengths based on regression models were slightly shorter than those based on 2016 data. Under RF-40 regulations and assuming states implement the seasons presented in **Table 1**, the private angling component season would be 2-3 days and the federal for-hire component season would be 48-49 days. The inconsistent seasons assumed for Gulf states in 2017 (see **Table 1**) reduce the private angling component federal season length nearly six-fold and catch over three-quarters of the ACT. The implementation of RF-40 reduced the private angling component federal season length by up to 17 days but increased the federal for-hire season by up to 34 days.

NOAA's revised National Standard 1 Guidelines indicate that if catch exceeds the ACL for a given stock more than once in four years, the system of ACLs and AMs should be revisited (74 FR 3180). The 20 percent ACT buffer was established by the Council in 2014 through a framework action to provide a 15 percent risk of exceeding the ACL (Gulf Council 2014). For the projections presented in this report, the mean risk of exceeding the component quota at a 20 percent ACT buffer was estimated at 2-6 percent for the federal for-hire component and 19-21 percent for the private angling component.

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Table 1. Approved and proposed 2017 Gulf state water recreational red snapper regulations.

State	Season (days)	Details
Florida*	78	Open Sat/Sun starting the first Saturday in May, then opening continuously starting the Saturday before Memorial Day through the Sunday following Independence Day, then reopening Fri/Sat/Sun in September and October, plus Labor Day
Alabama	67	Open May 26 through July 31
Mississippi*	102	Open May 26 to September 9
Louisiana	≤334	Opened Feb 1, may close when self-imposed 'quota' of 1,045,461 lb ww caught (based on 18.41% PVT quota and 11.6% of FFH quota)[1]
Texas	365	Open year-round, 4-fish bag limit in state waters, 15" min. size limit

*Not finalized

[1] *Louisiana's self-imposed recreational red snapper landing limit is based on 50% of the average percentages landed by each component between 1986 and 2013 (2010 excluded) and 50% of the average percentages landed by each component between 2006 and 2013 (2010 excluded). Under these computations, Louisiana's historic share of the harvest for private anglers is 18.41% of the Gulfwide harvest by private anglers and for charter 11.60% of the Gulfwide harvest by the for-hire sector. In 2016 LA Creel estimated that Louisiana's self-imposed recreational limit of 1,116,732 was exceeded by 1,094 pounds. Therefore for 2017 the self-imposed limit reflects a change in the Gulfwide recreational ACL and removal of 2016 overages (715,171 + 330,290 – 1,094 = 1,044,367 pounds).*

Table 2. Data inputs used in projections.

Source	Time Period	Details
Marine Recreational Information Program (MRIP)	2004-2016	Landings and PSE by wave, 2004-2013 landings recalibrated for changes in angler intercept survey; 2014-2016 from SEFSC Recreational ACL Database (Mar 2017)
Texas Parks and Wildlife Department (TPWD)	2004-2016	Landings 2004-2015 by wave from SEFSC Recreational ACL Database (Mar 2017); 2016 landings and PSEs 2004-2016 obtained from TPWD staff; 2016 landings parsed to MRIP wave and assigned weights based on 2015 data
Louisiana Department of Wildlife and Fisheries (LDWF)	2014-2016	Weekly landings and error estimates from LDWF staff
Southeast Region Headboat Survey (SRHS)	2004-2016	Monthly landings from SEFSC Recreational ACL Database (Mar 2017); expansion factors from CRNF file from SRHS staff
Southeast Fisheries Science Center Recreational Annual Catch Limit Dataset (SEFSC ACL data)	2004-2016	Average weights by year and mode of fishing

Table 3. 2016 Gulf of Mexico recreational red snapper landings, by mode and state.

Component	Private Angling	Federal For-Hire
FL	1,711,156	772,587
AL	2,018,210	834,343
MS	351,753	147,319
LA	956,403	21,188
TX	150,379	358,567
ACT	3,320,000	2,434,000
Quota	4,150,000	3,042,000
ACL	7,192,000	
%ACT	156%	88%
%Quota	125%	70%
%ACL	102%	

Sources: SEFSC MRIP-Based Recreational ACL Data (MRIP, SRHS Waves 1-6), LA Creel, TPWD for Texas private and charter 2016, parsed to wave and assigned weights using 2015 ACL Data.

Table 4. Retrospective analysis of state catches and season lengths in 2016 relative to those predicted in SERO-LAPP-2016-04.

A. State catches (lbs ww)

	FL	AL	MS	LA	TX
Predicted (mean)	739,285	73,113	42,145	554,155	181,283
Observed (mean)	1,125,221	305,770	207,207	789,035	94,069
Error:	0.52	3.18	3.92	0.42	-0.48

B. State season (days)

	FL	AL	MS	LA	TX
Predicted	78	43	120	156	365
Observed	85	66	102	279	365
Error:	0.09	0.53	-0.15	0.79	0.00

Table 5. Percent residual deviance explained by significant covariates in final regression model configurations, by state/region and mode (CBT: charter, PVT: private, HBT: headboat).

	Mode	Florida			Alabama			Mississippi			Louisiana			Texas		
		CBT	PVT	HBT	CBT	PVT	HBT	CBT	PVT	HBT	CBT	PVT	HBT	CBT	PVT	HBT
Average Weight	Year														86	36
	Year of Rebuilding	91														
	Weekend Days					38					87	72				
	State Days			92												
	SSB		90		98	90	93							74		
	Fuel Price						50									
	Per Capita GDP	27													57	61
	Fishable Days (WSP)			27	38										38	
	Fishable Days (WH)															56
	Google Trends															
Catch Rate	Year		43	37		80		57								
	Year of Rebuilding					72						48				91
	Weekend Days															22
	State Days						86									
	SSB										29					
	Fuel Price															
	Per Capita GDP				31	5									67	
	Fishable Days (WSP)	23				64										
	Fishable Days (WH)															
	Google Trends				79											

Table 6. Directional change in regression-estimated 2017 mean weights and catch rates relative to observed 2016 values, by state and mode. Note: '~' denotes within 5% of 2016 observation.

Mean Weight

Mode	FL	AL	MS	LA	TX
Charter	↓	~	↑	↑	↑
Private	~	~	↓	↑	↑
Headboat	~	~	↑	↑	~

Catch Rate

Mode	FL	AL	MS	LA	TX
Charter	↑	↓	↓	~	↑
Private	↑	↑	↓	↑	↑
Headboat	↑	↓	↓	↑	↑

Table 7. Projected catch rates, season lengths, and probabilities of exceeding component quotas and recreational ACL based on 1000 bootstrapped projection runs.

| Model | Catch Rate (lbs/day) | | Season Length (days) | | P(exceed quota) | | P(exceed ACL) |
	Federal For-Hire	Private Angling	Federal For-Hire	Private Angling	Federal For-Hire	Private Angling	Recreational
2016 as proxy	46,140 ± 8,194	231,178 ± 77,163	49	3	6%	21%	7%
Regression	48,552 ± 5,379	297,005 ± 61,395	48	2	2%	19%	8%
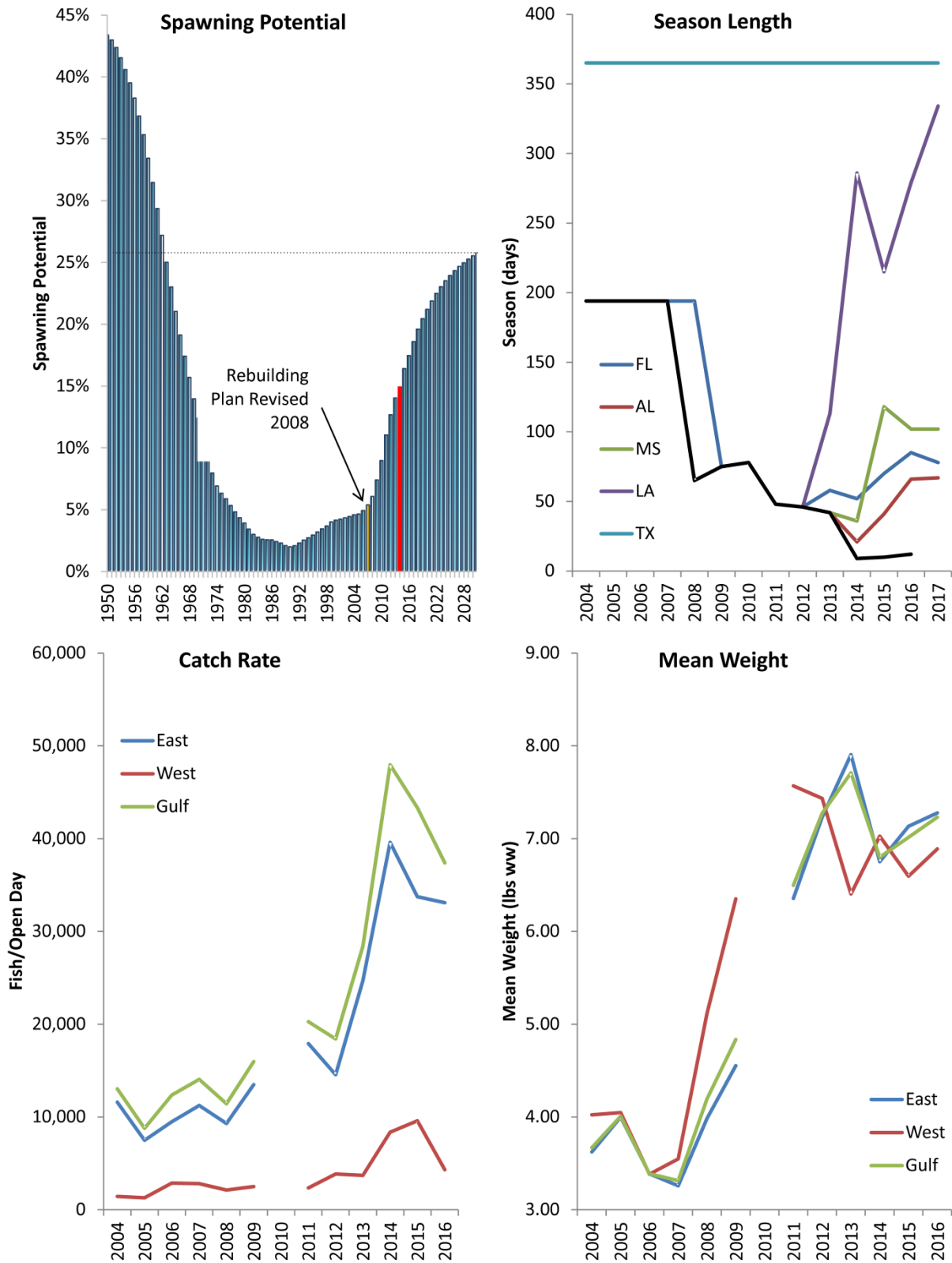
Figure 1. Changes in red snapper spawning potential, federal (black line) and state recreational season lengths, catch rates, and mean weights associated with the rebuilding of red snapper.
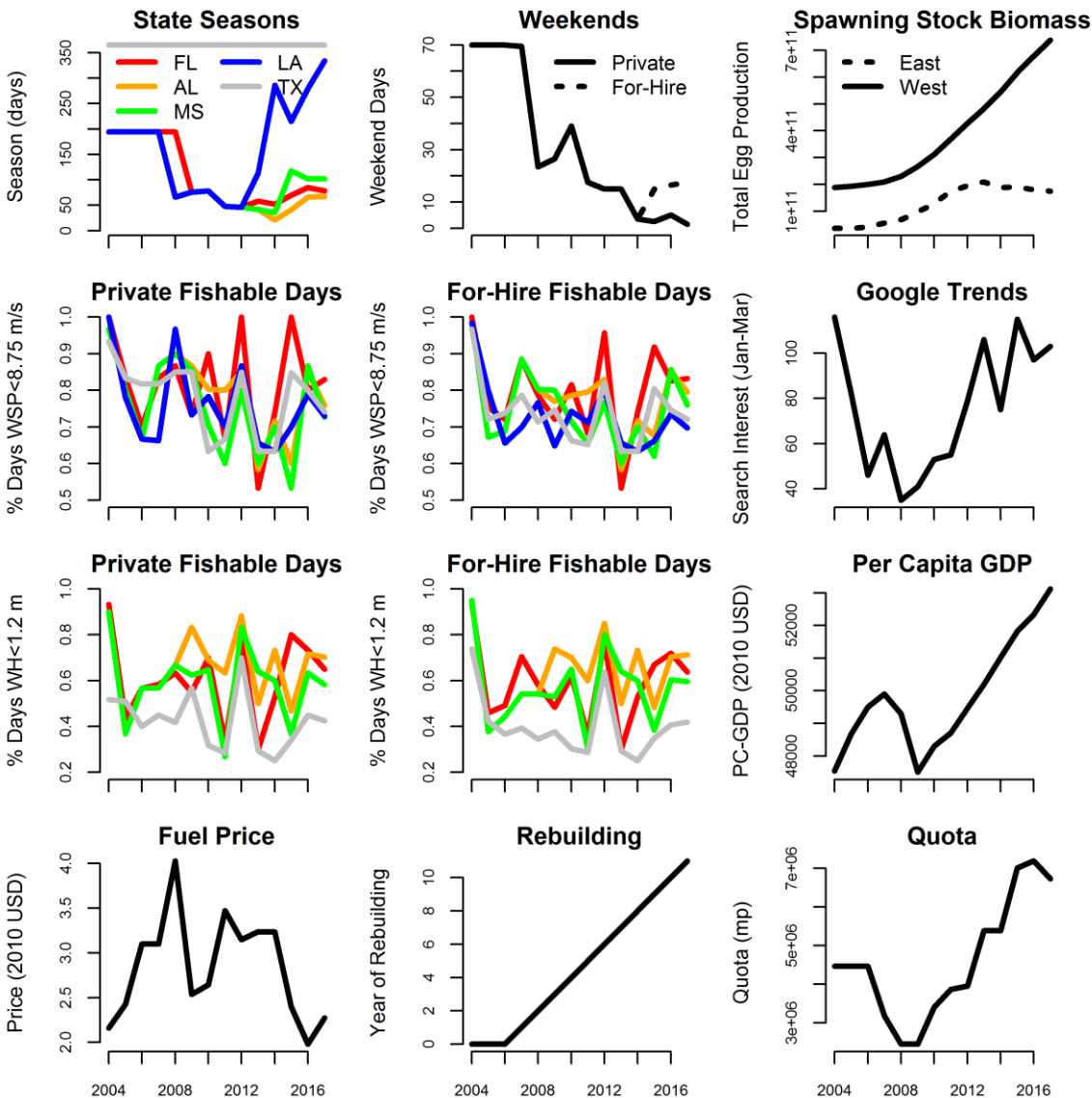
Figure 2. Covariates considered in regression models for federal catch rates and average weights, including: (1) state season lengths, (2) open weekend days, (3) spawning stock biomass, (4) fishable days for private angling component based on wind speeds < 8.75 m/s, (5) fishable days for federal for-hire component based on wind speeds < 8.75 m/s, (6) Google Trends in searches for "red snapper season," (7) fishable days for private angling component based on wave heights < 1.2 m, (8) fishable days for federal for-hire component based on wave heights < 1.2 m, (9) per capita gross domestic product (GDP), (10) mean Gulf of Mexico fuel price, (11) year in the red snapper rebuilding plan, and (12) red snapper recreational quota.

FLORIDA CHARTER
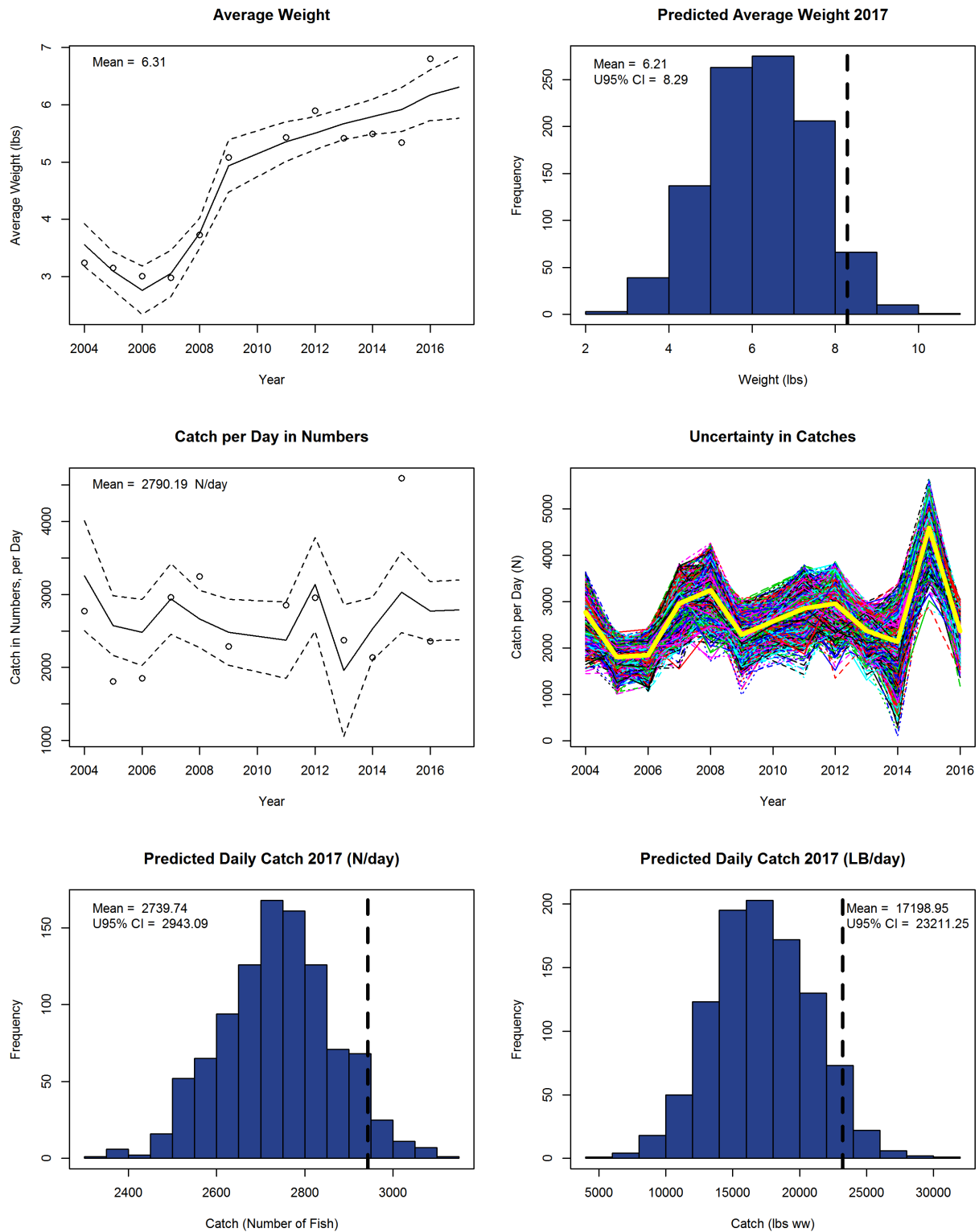
Figure 3A. Forecast for Florida charter vessel mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.
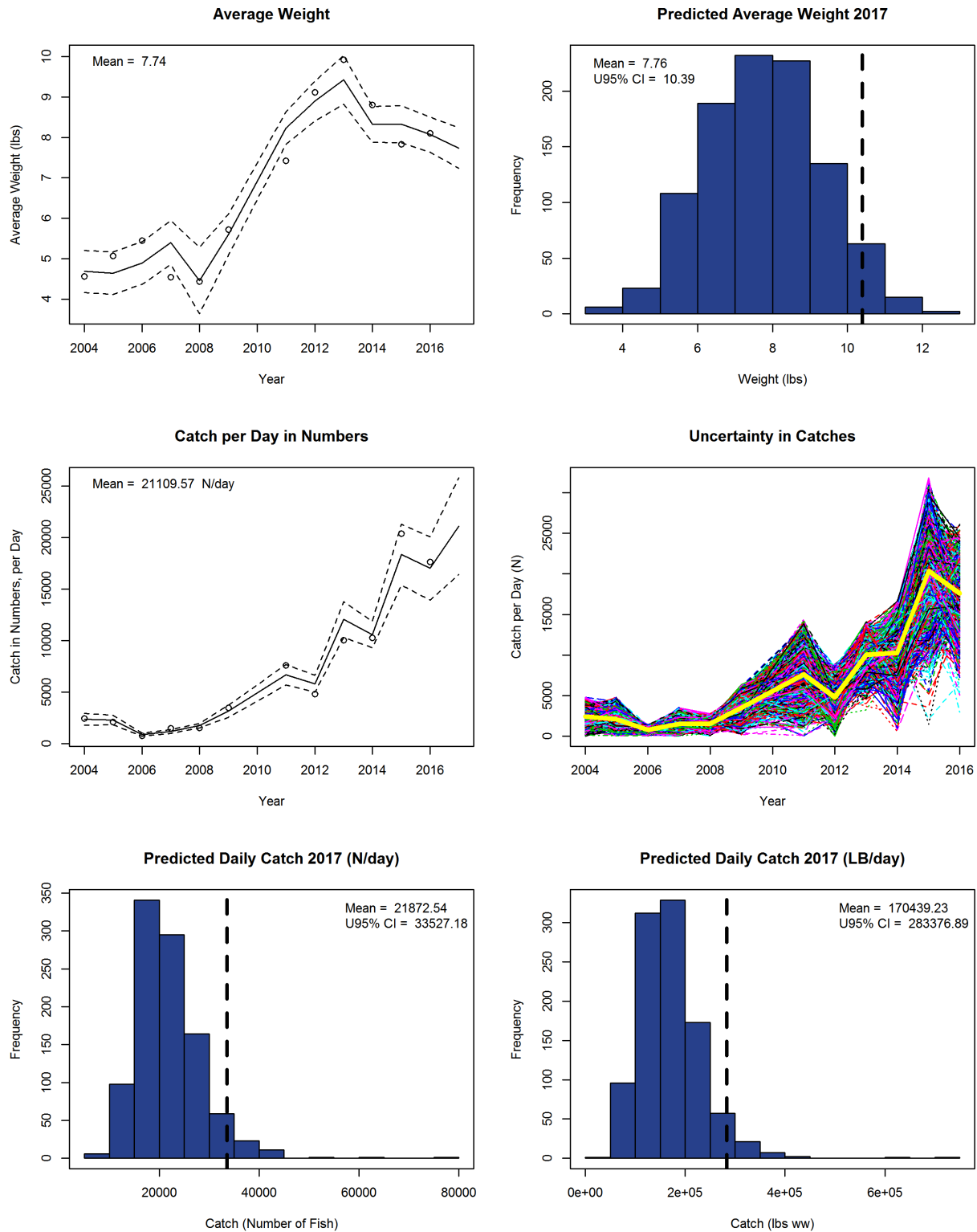
FLORIDA PRIVATE
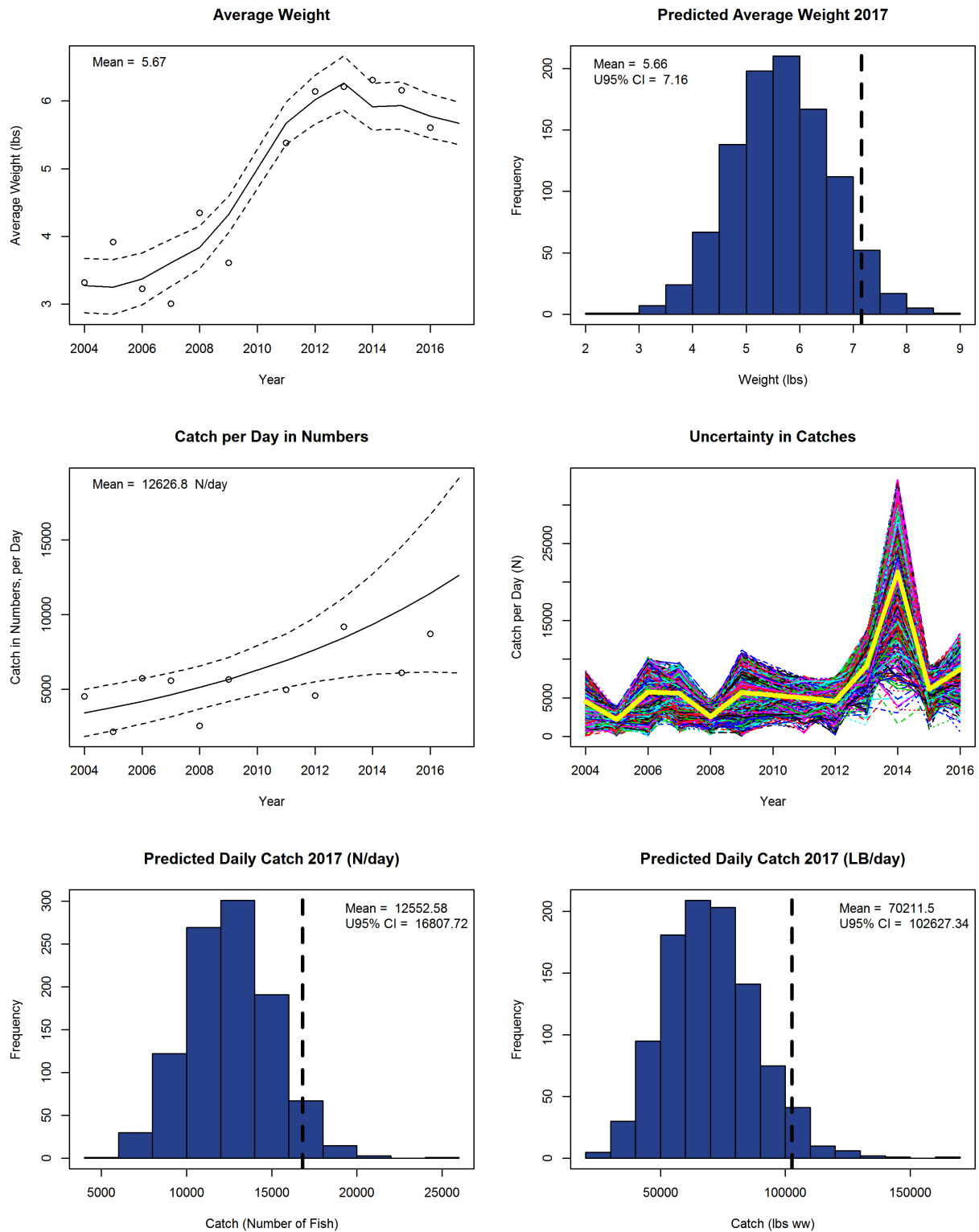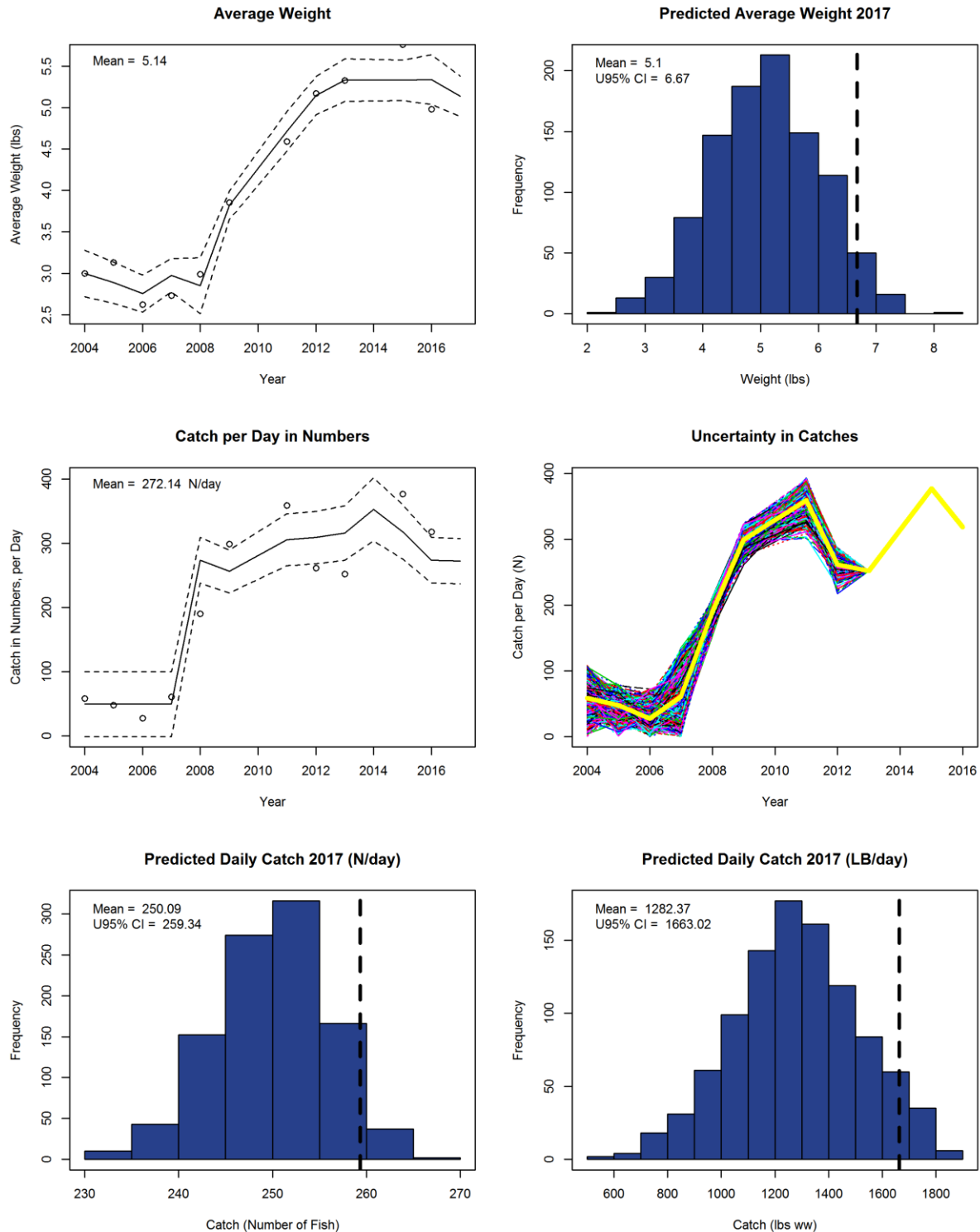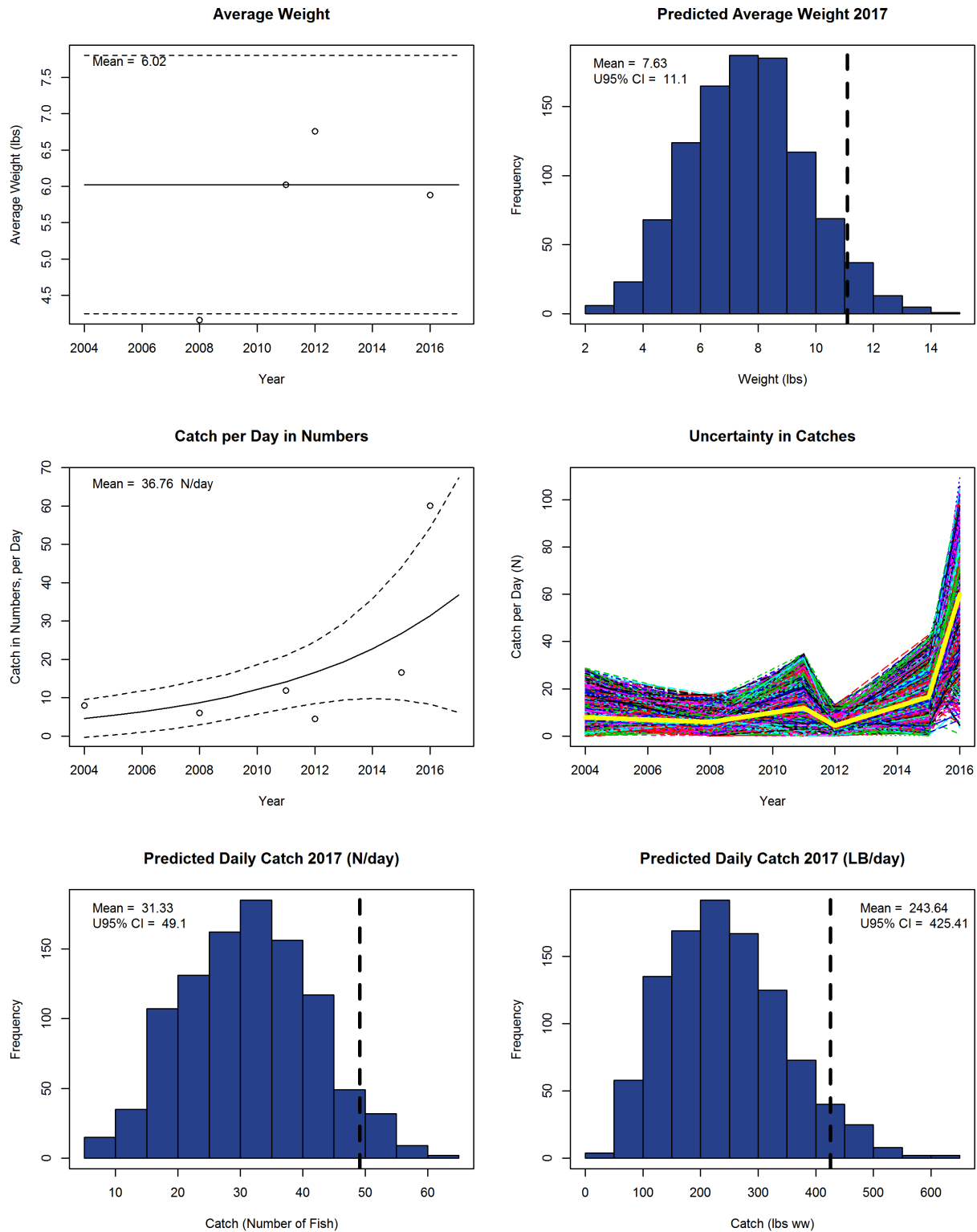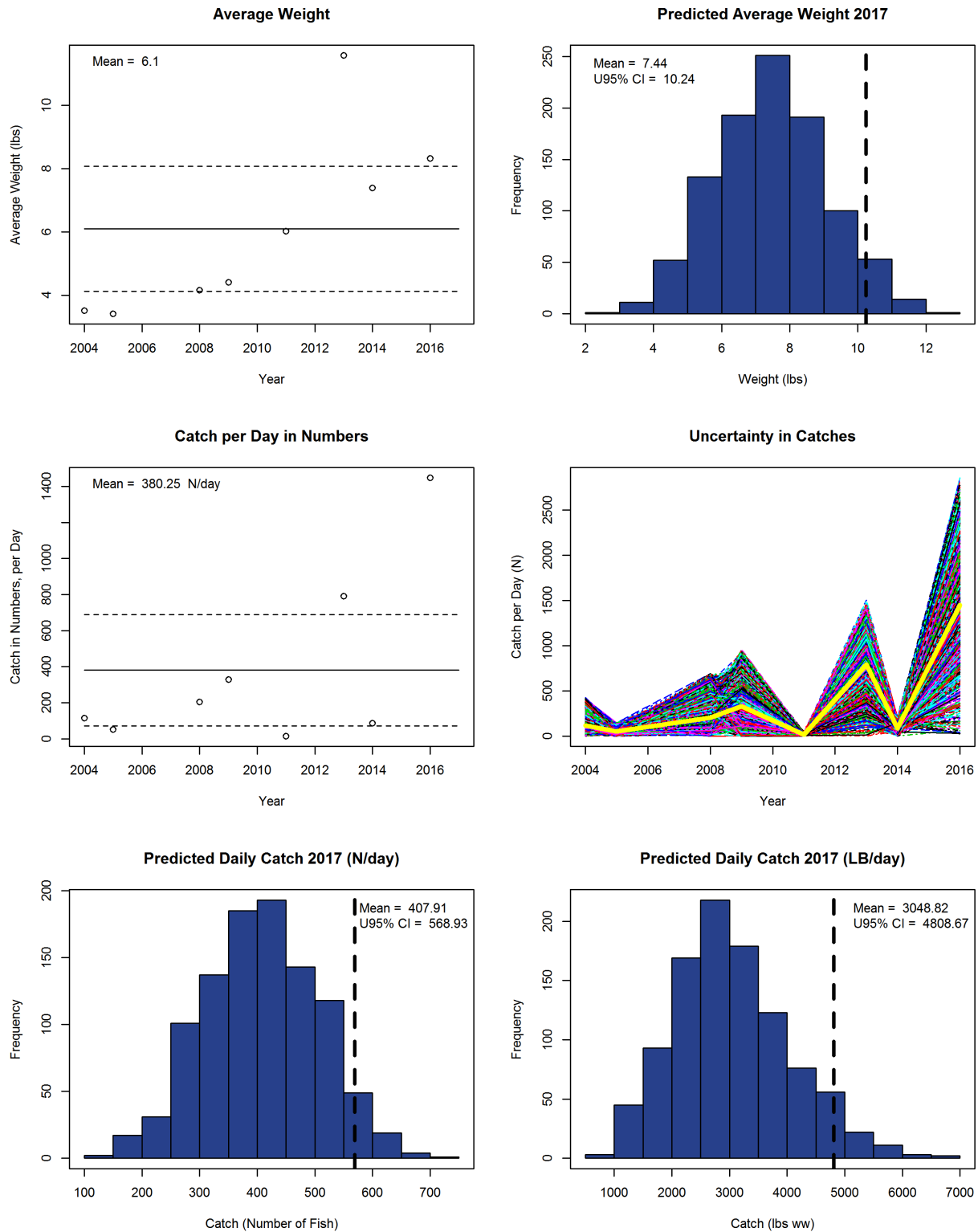

Figure 3B. Forecast for Florida private angler mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.

FLORIDA HEADBOAT
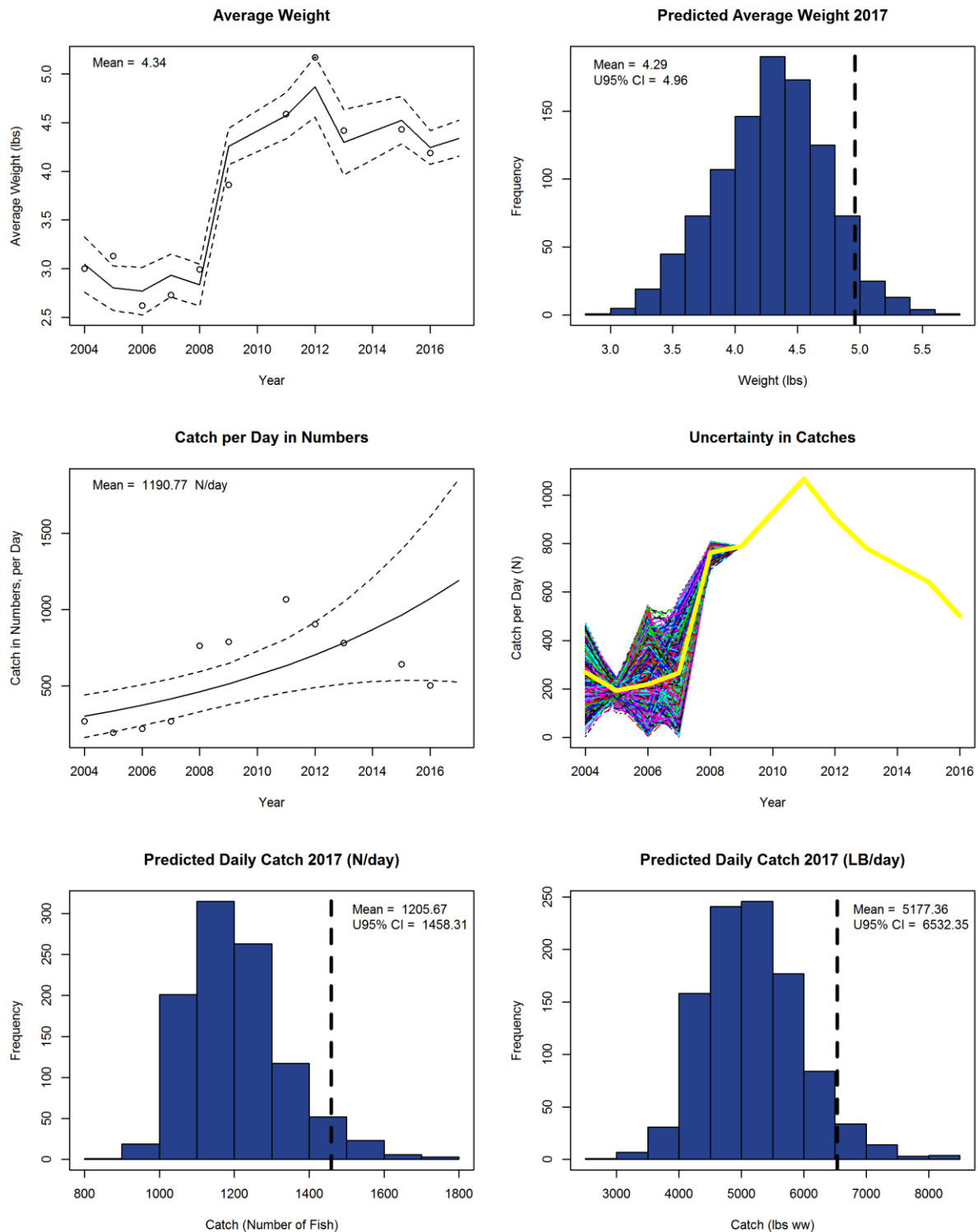
Figure 3C. Forecast for Florida headboat mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.

ALABAMA CHARTER
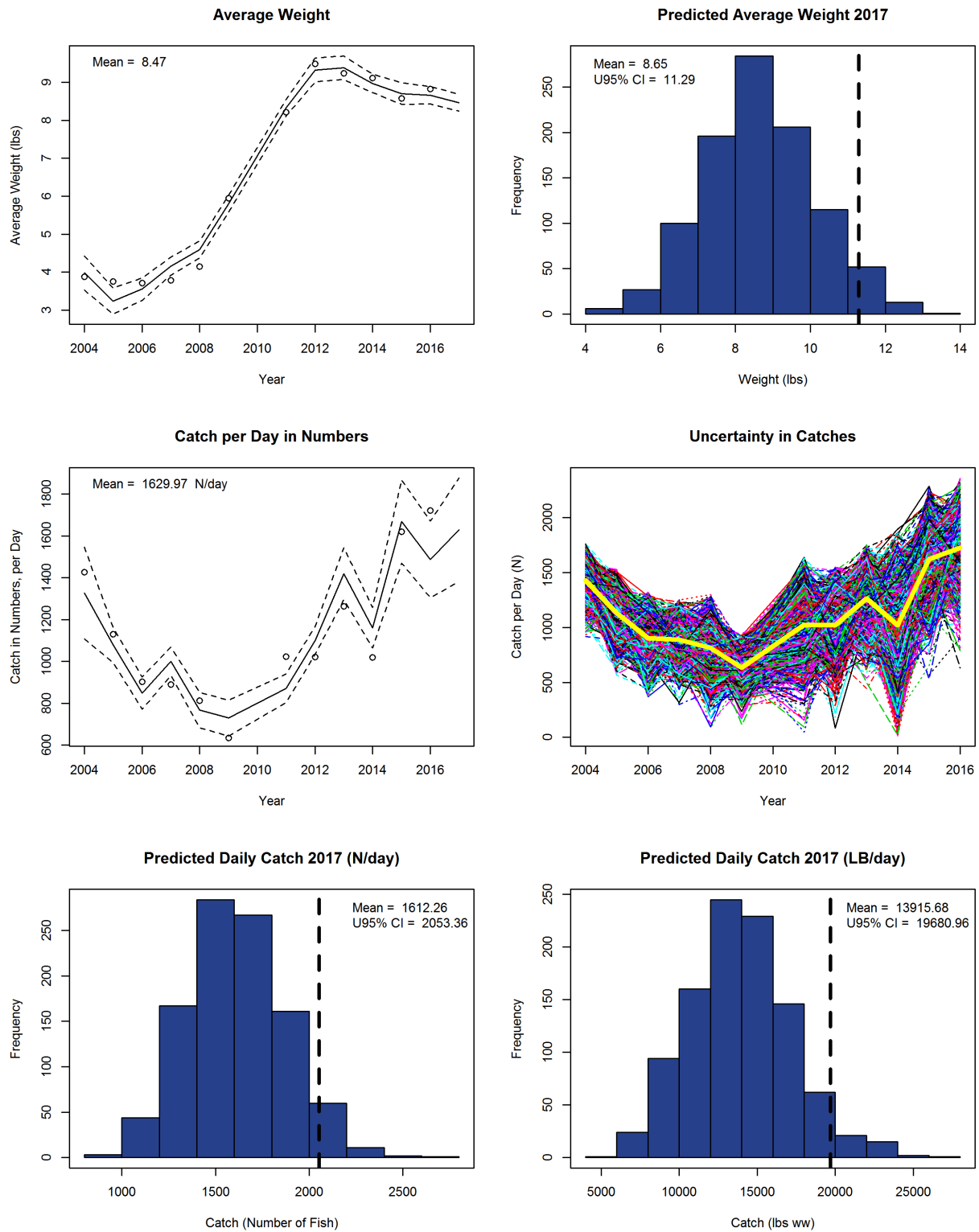
Figure 4A. Forecast for Alabama charter vessel mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.

ALABAMA PRIVATE

Figure 4B. Forecast for Alabama private angler mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.
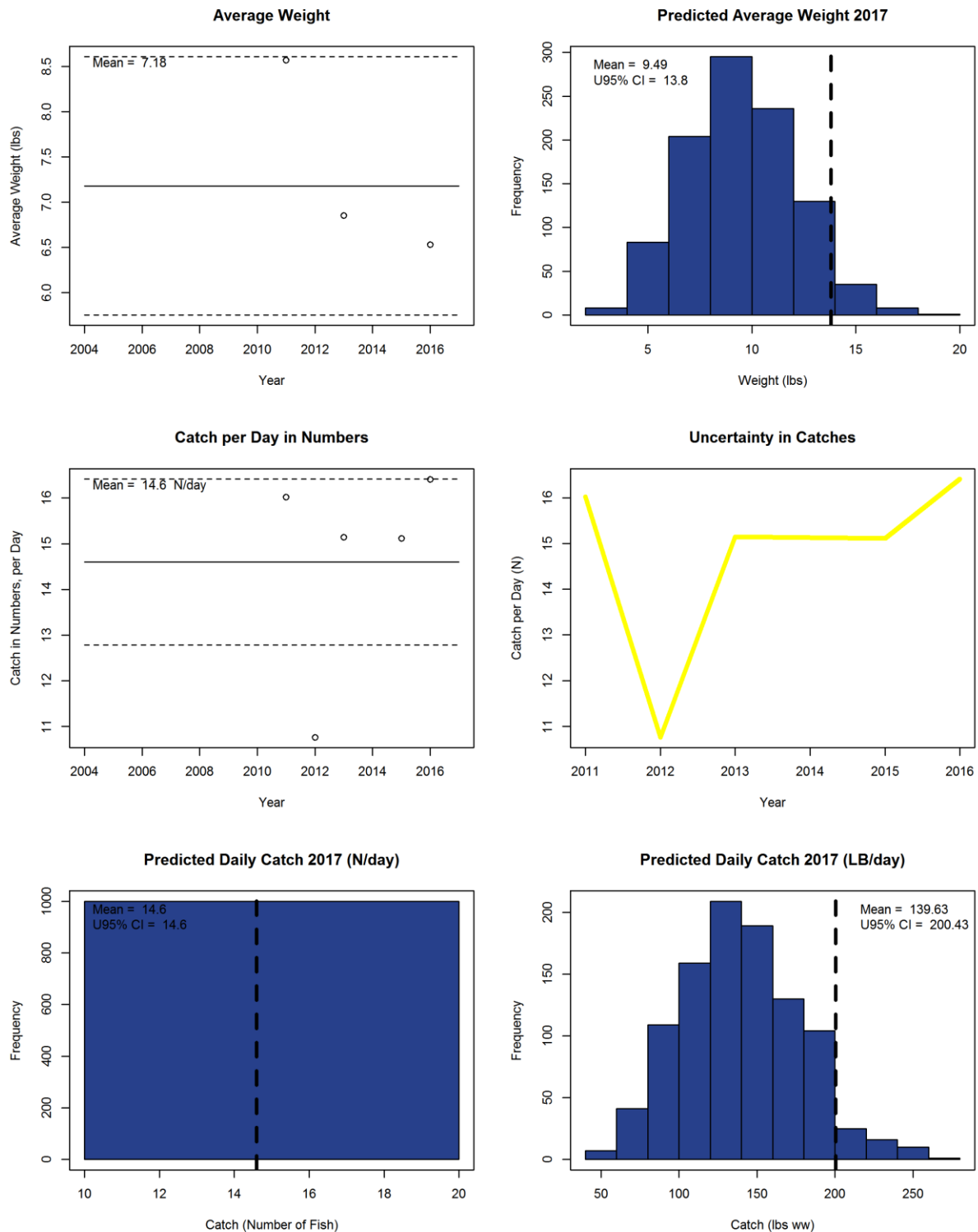
ALABAMA HEADBOAT

Figure 4C. Forecast for Alabama headboat mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.
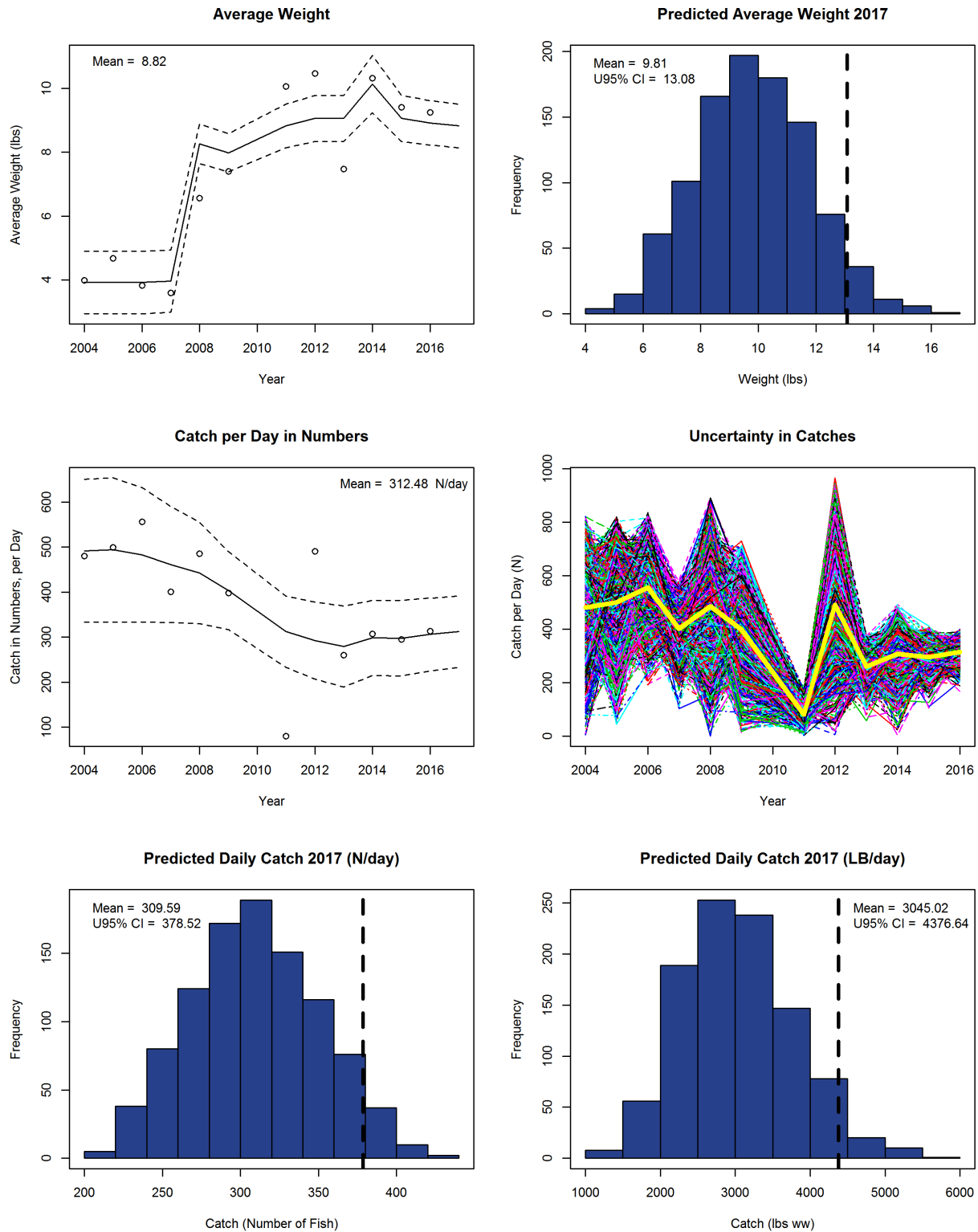
MISSISSIPPI CHARTER

Figure 5A. Forecast for Mississippi charter vessel mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.

MISSISSIPPI PRIVATE
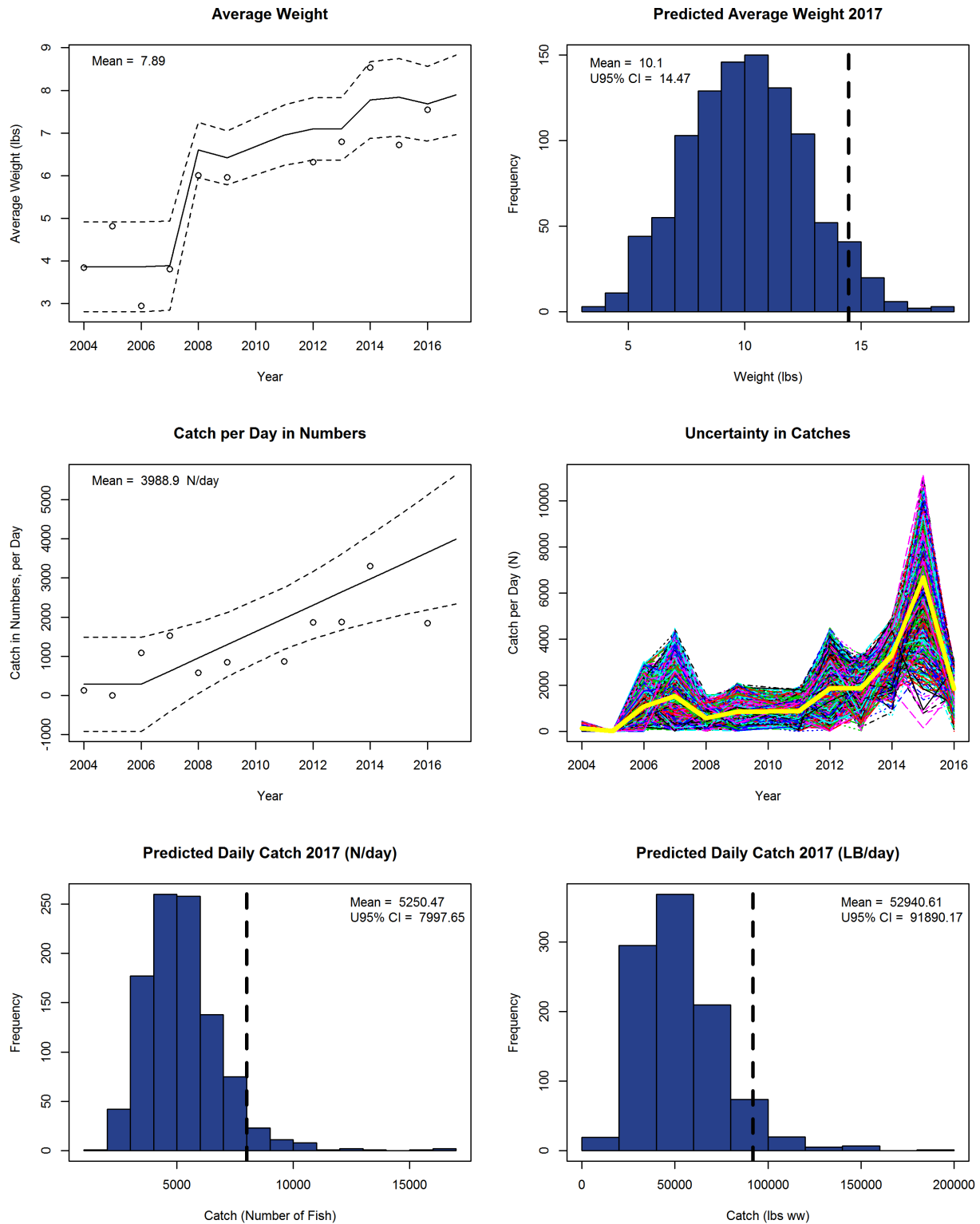

Figure 5B. Forecast for Mississippi private angler mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.

MISSISSIPPI HEADBOAT

Figure 5C. Forecast for Mississippi headboat mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.

LOUISIANA CHARTER

Figure 6A. Forecast for Louisiana charter vessel mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.
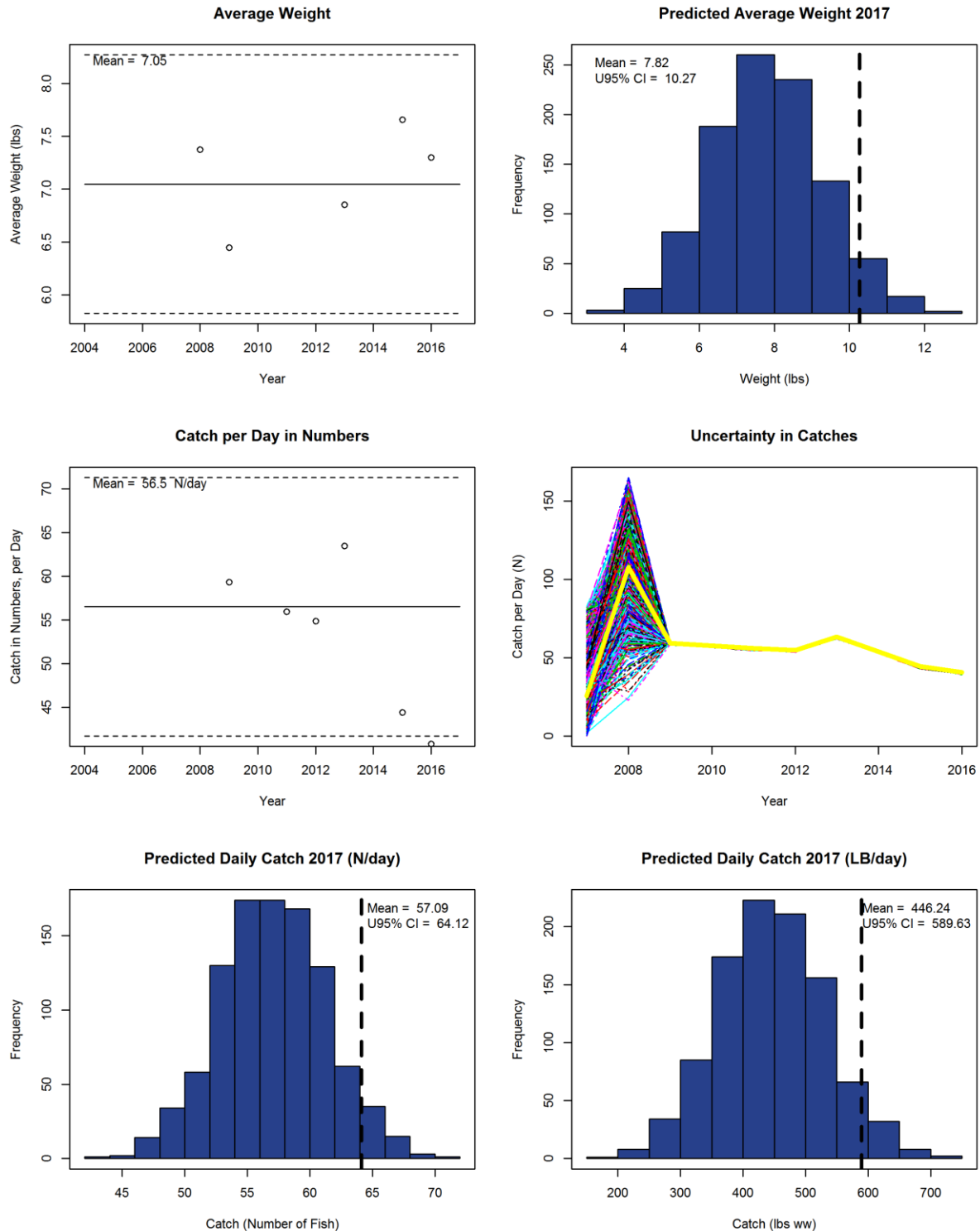
LOUISIANA PRIVATE

Figure 6B. Forecast for Louisiana private angler mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.

LOUISIANA HEADBOAT

Figure 6C. Forecast for Louisiana headboat mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.
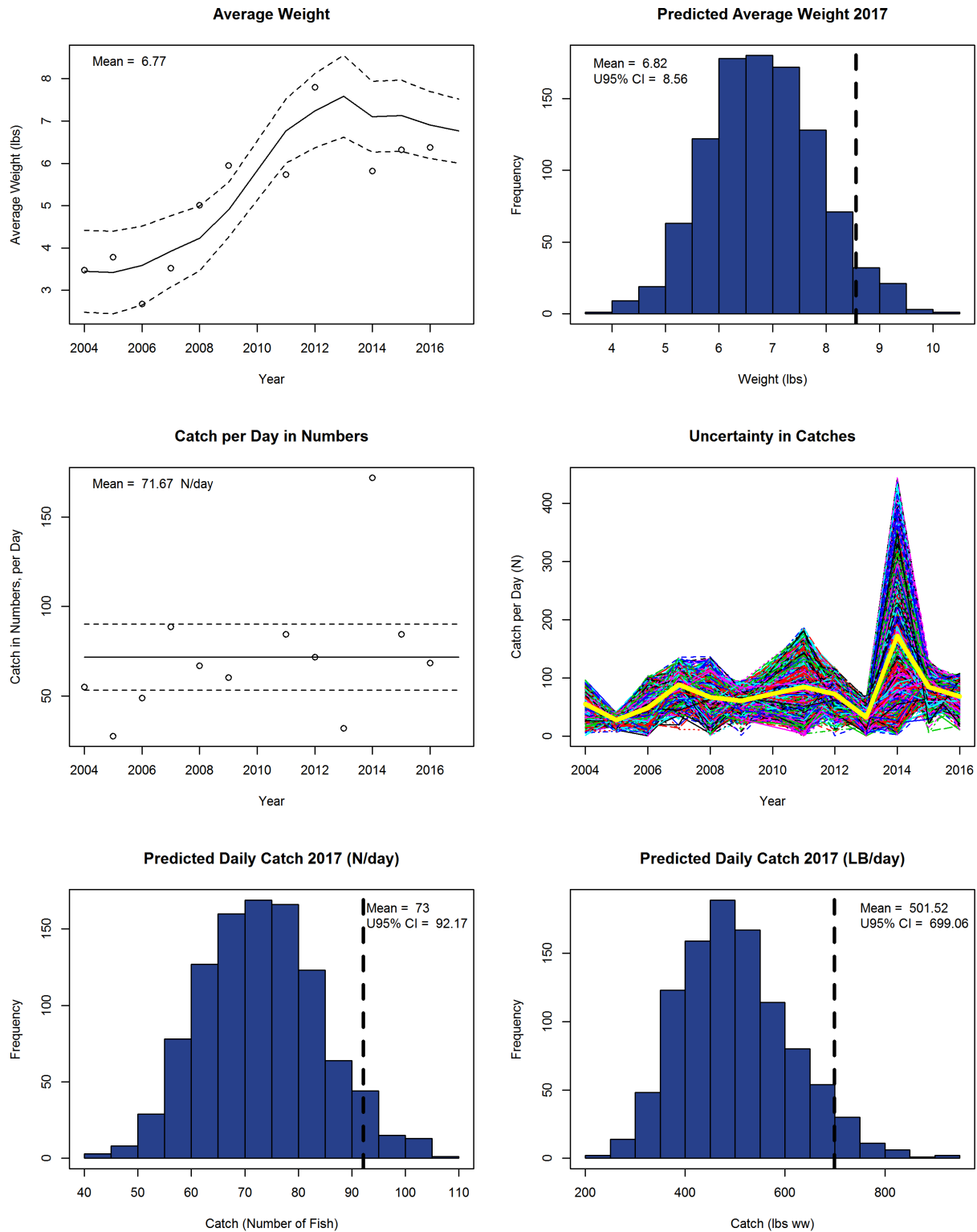
TEXAS CHARTER

Figure 7A. Forecast for Texas charter vessel mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.
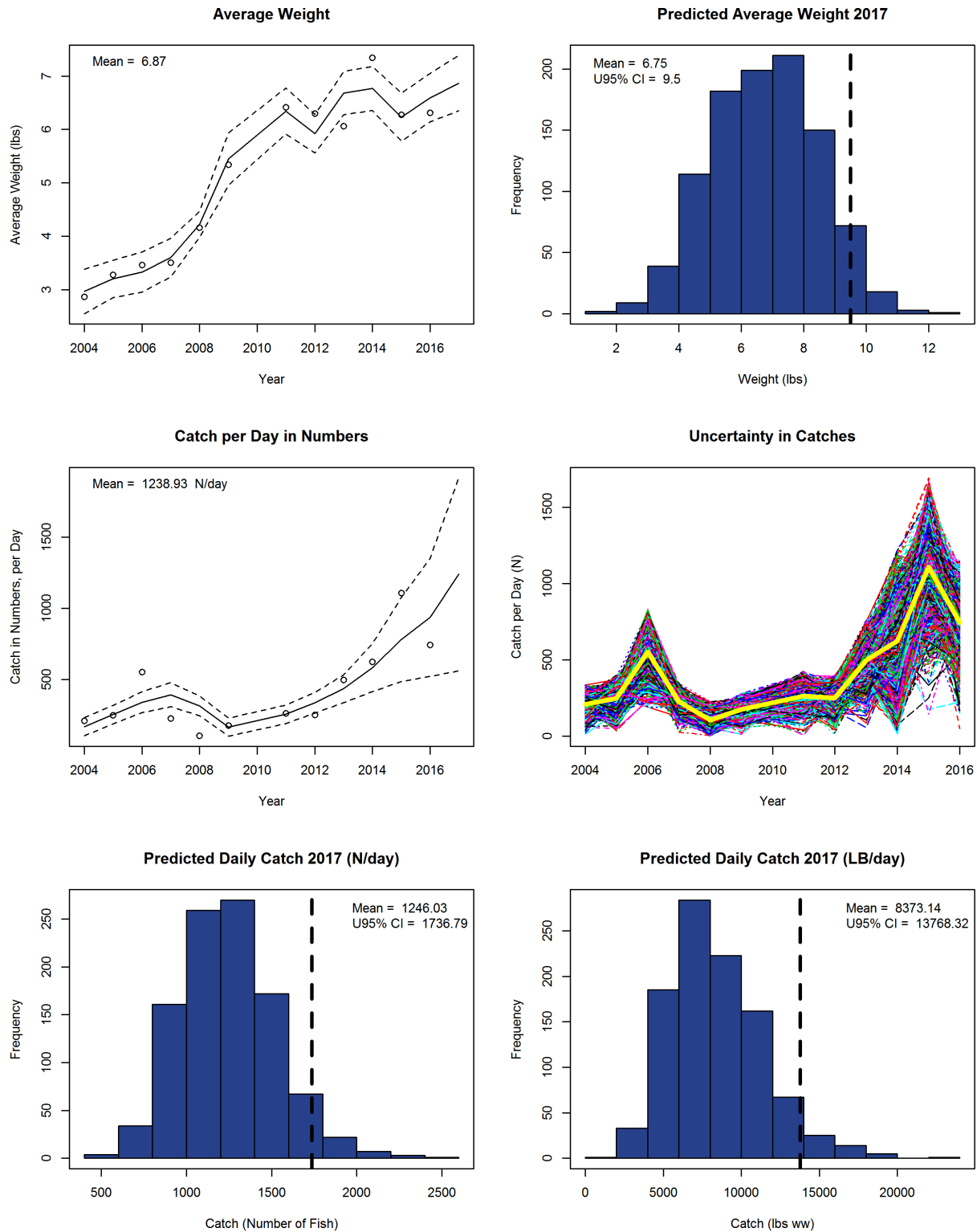
TEXAS PRIVATE

Figure 7B. Forecast for Texas private angler mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.
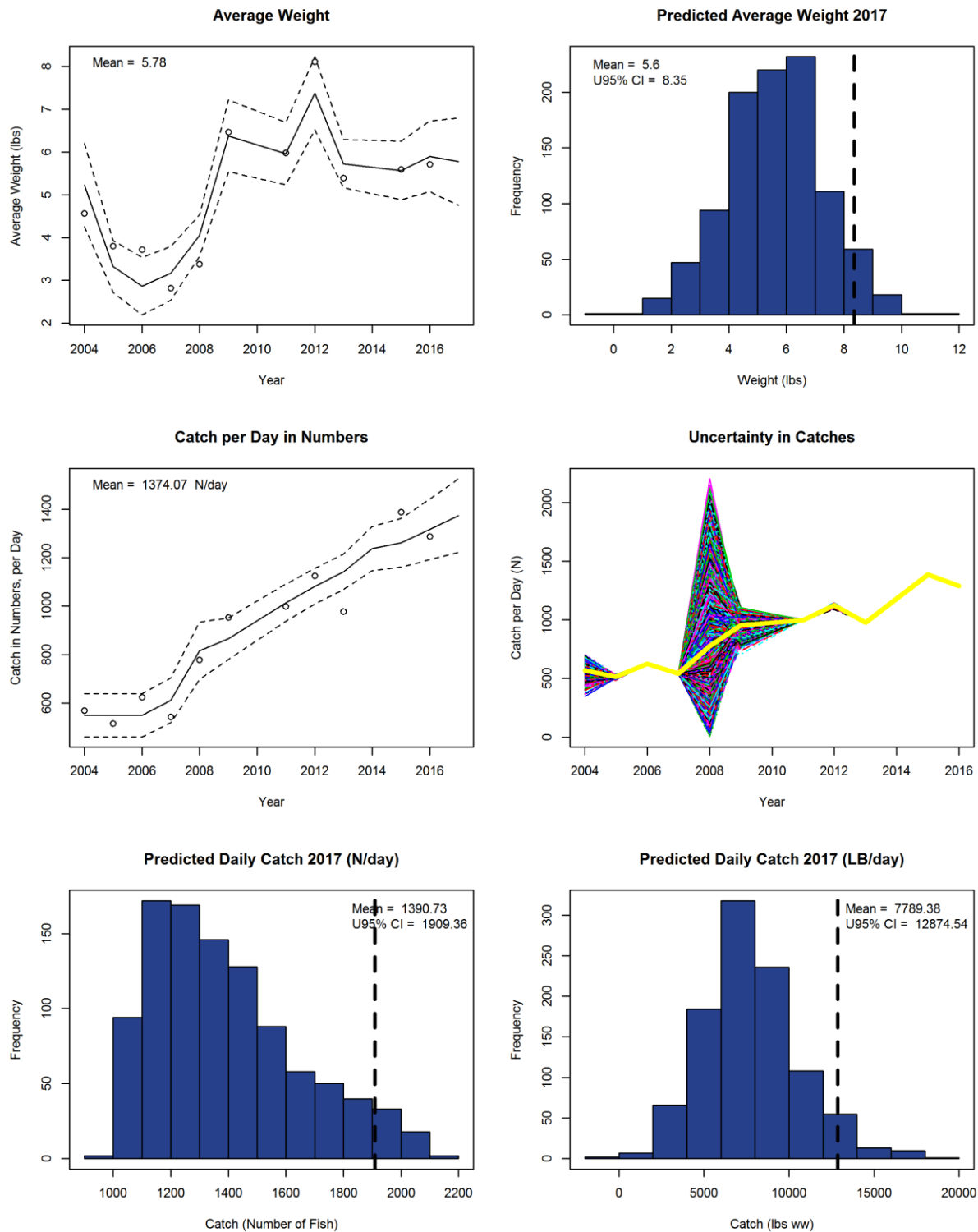
TEXAS HEADBOAT

Figure 7C. Forecast for Texas headboat mode average weight and catch per day, showing basic model fits and bootstrapped run histograms accounting for uncertainty in weight and catch estimates.
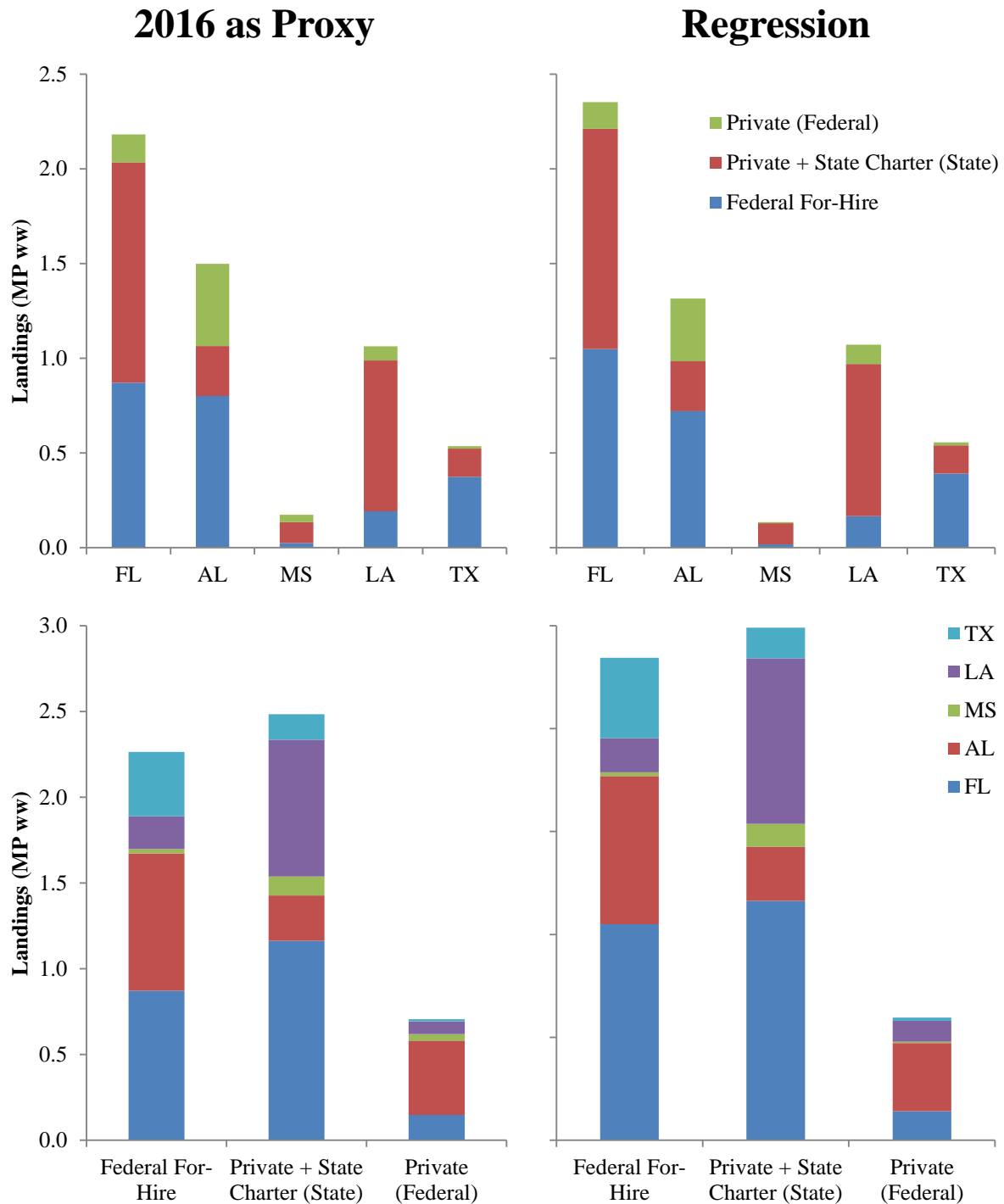
Figure 8. 2017 forecast landings under different projection models, showing landings by mode broken out by state (top) and landings by state broken out by mode (bottom).
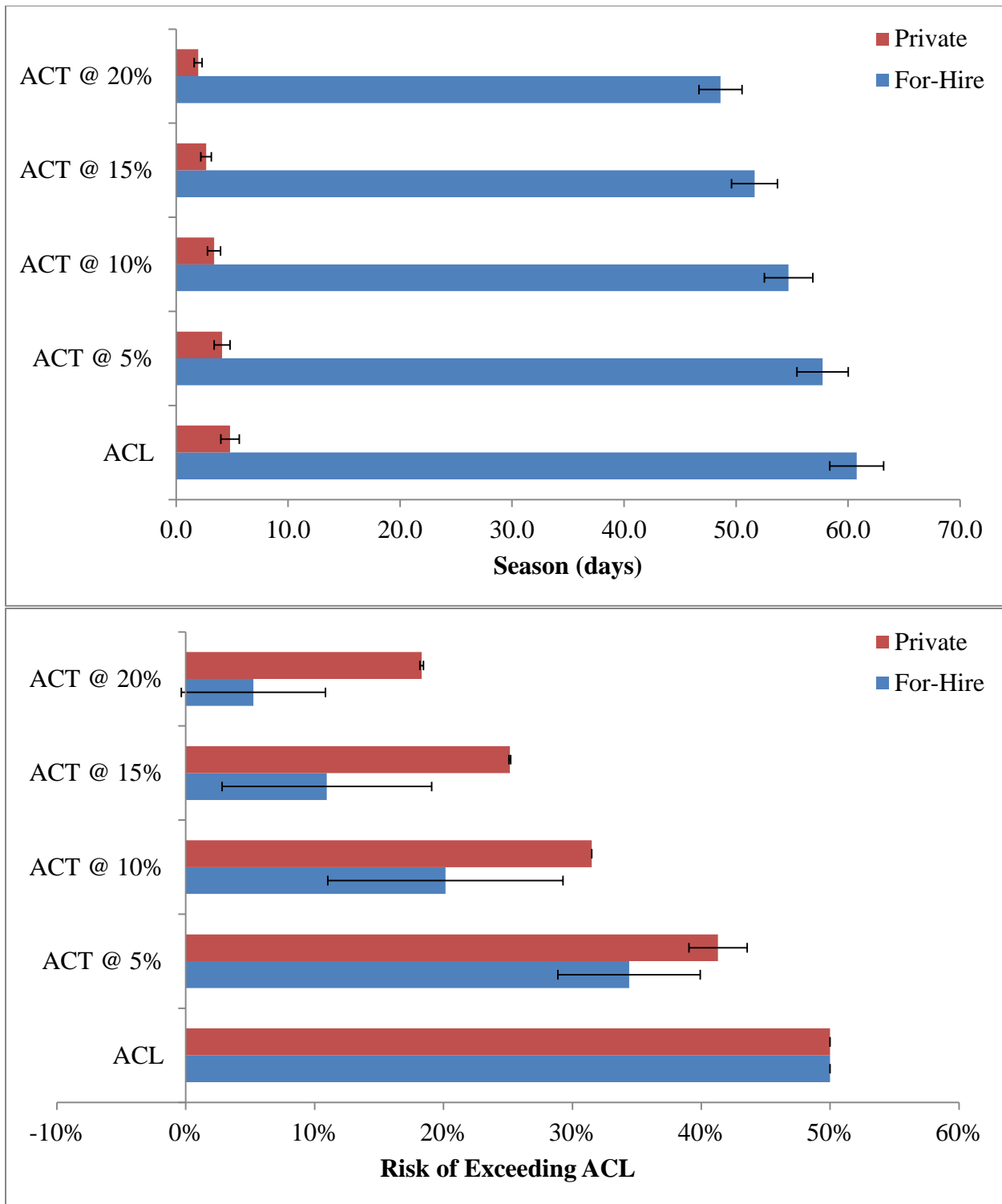
Figure 9. Mean season lengths and percentage of 1000 bootstrapped runs of projected landings that exceeded component quota across 1000 bootstrapped runs at different ACT buffer levels. Models configured with federal season lengths set to have mean landings equal to ACT. Error bars denote standard deviation.

Table S-1. Seasonal (*s*) autoregressive integrated moving average (SARIMA) (*p,d,q*)x(*P,D,Q*)s model combinations evaluated, where the autoregressive component (*p*) represents the lingering effects of previous observations, the integrated component (*d*) represents temporal trends, the moving average component (*q*) represents lingering effects of previous random shocks (or error), and s denotes the seasonal time step. As recreational landings are primarily collected in 2-month waves, *s* was set to 6. A "1" denotes an active component in the model.

ARIMA(*p,d,q*)X(*P,D,Q*)s Model
ARIMA(0,1,1)X(0,1,1)*s*
ARIMA(1,0,0)X(0,1,1)*s*
ARIMA(0,0,1)X(0,1,1)*s*
ARIMA(0,1,1)X(1,1,0)*s*
ARIMA(1,0,0)X(1,1,0)*s*
ARIMA(0,0,1)X(1,1,0)*s*
ARIMA(1,1,0)X(0,1,1)*s*
ARIMA(1,1,0)X(1,1,0)*s*

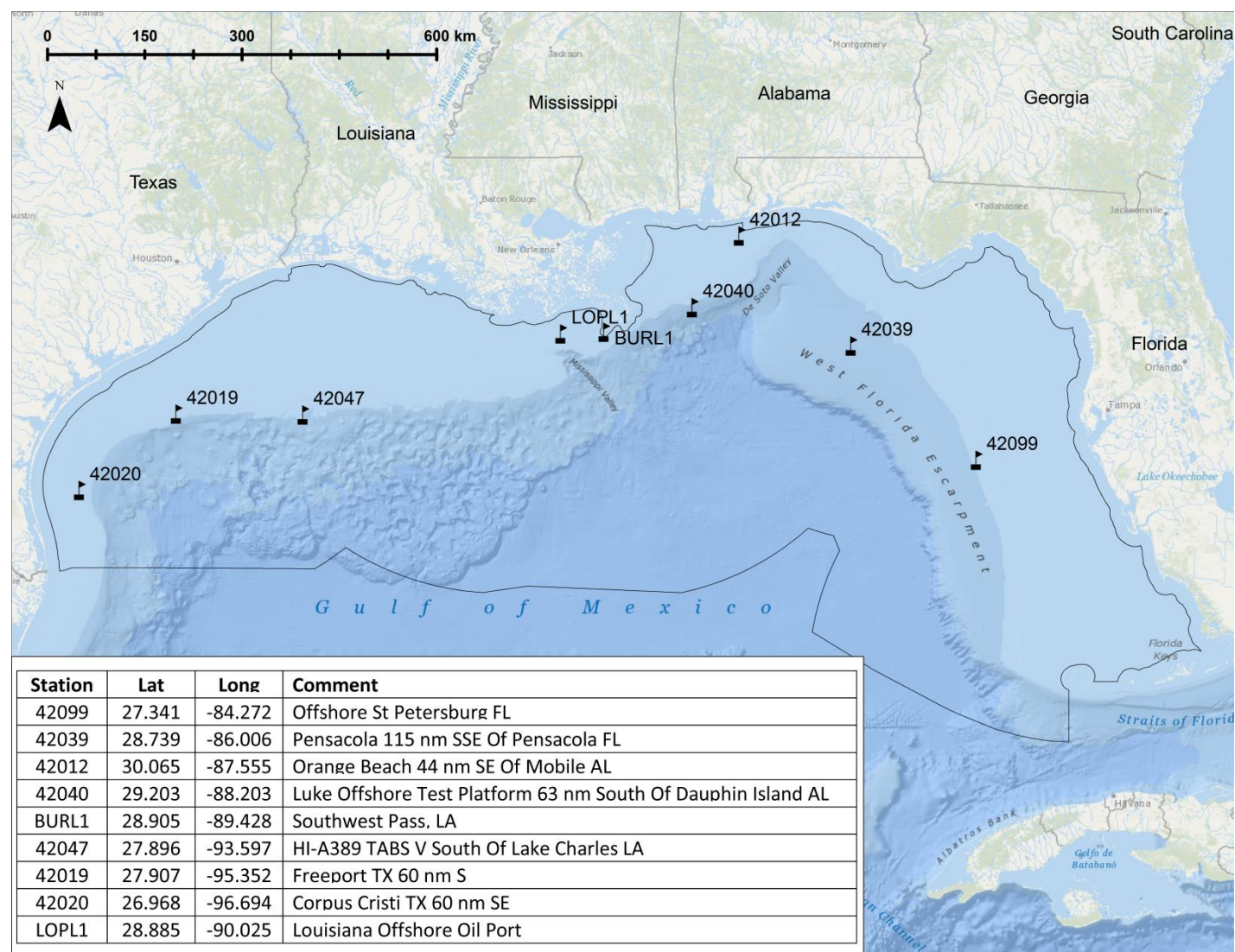| Station	Lat	Long	Comment
42099	27.341	-84.272	Offshore St Petersburg FL
42039	28.739	-86.006	Pensacola 115 nm SSE Of Pensacola FL
42012	30.065	-87.555	Orange Beach 44 nm SE Of Mobile AL
42040	29.203	-88.203	Luke Offshore Test Platform 63 nm South Of Dauphin Island AL
BURL1	28.905	-89.428	Southwest Pass, LA
42047	27.896	-93.597	HI-A389 TABS V South Of Lake Charles LA
42019	27.907	-95.352	Freeport TX 60 nm S
42020	26.968	-96.694	Corpus Cristi TX 60 nm SE
LOPL1	28.885	-90.025	Louisiana Offshore Oil Port

Figure S-1. Locations of NOAA Data Buoys used as sources for archived sustained wind speed and wave height data.
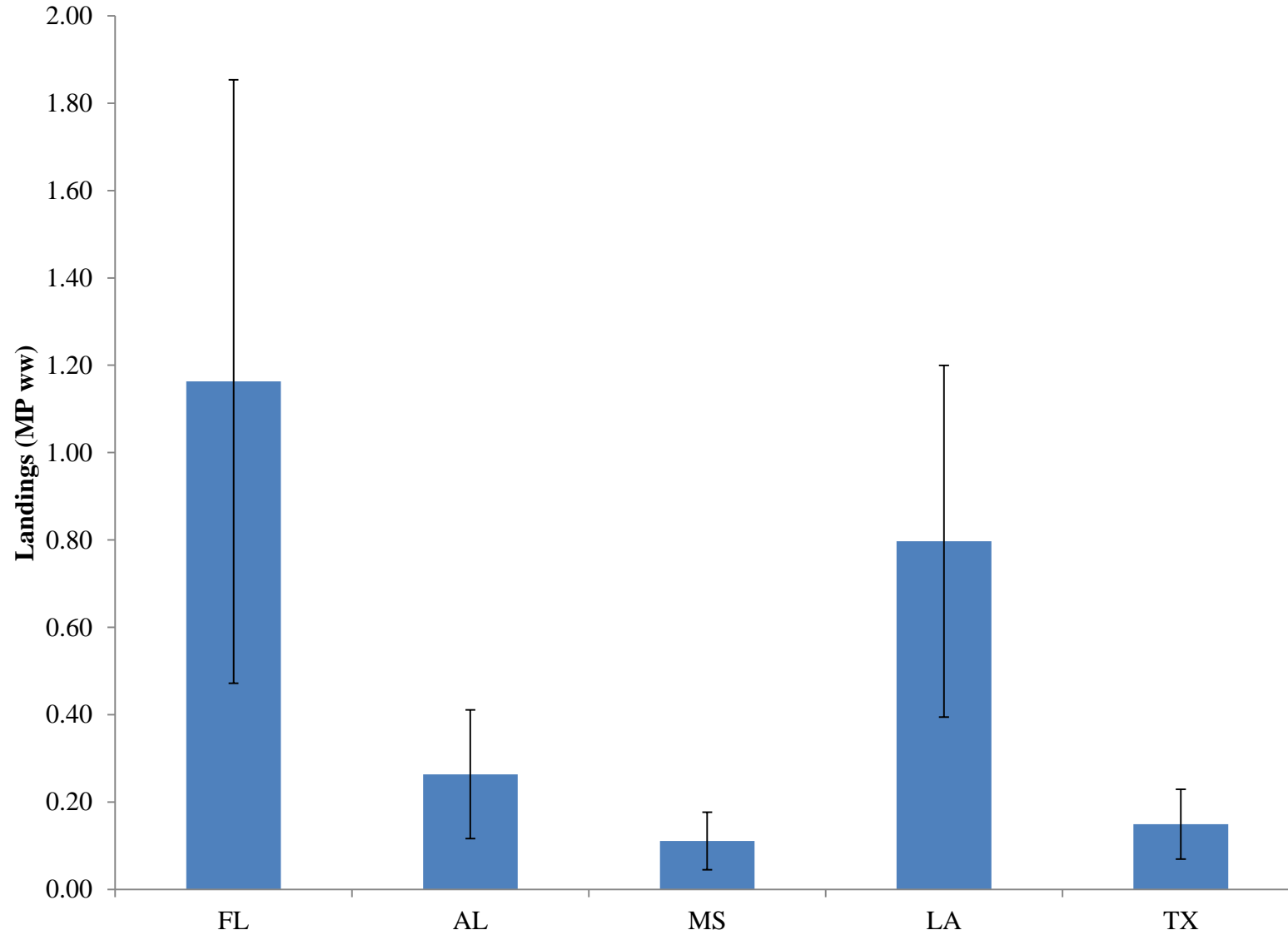
Figure S-2. Predicted landings in 2017 for state seasons indicated in Table 1. Error bars denote standard deviation.